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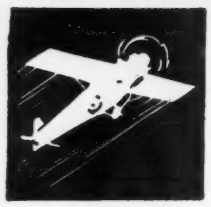

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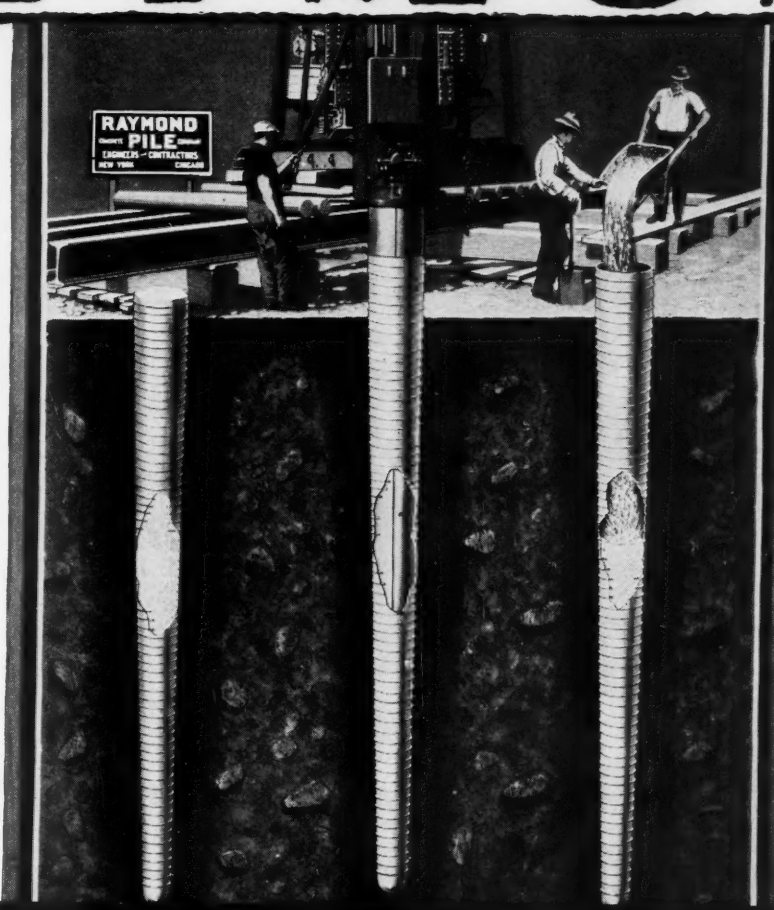

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THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XI MAY, 1930 NUMBER 4

The American Aircraft Industry

The state of its finances, and the field for its expansion

By EDWARD P. WARNER '17
Editor, *Aviation*

FINANCIAL STATUS

AT the end of the World War companies which were manufacturing aircraft might have been divided into three categories:

I. Companies that had gone into the business of manufacturing aircraft purely as a war measure, and that got out of the business as soon as the war was over at their first opportunity.

II. Companies that had been in the business before the war started, and expecting a slump in operations with the loss of the military market at its close, drastically scaled down all operations in order to cut operating costs.

III. Companies de[illegible]ded by the belief that although the war was over and the military demand gone, they would be able to sell as many or more airplanes than they had been selling while the war lasted. This latter class of optimists were cheered on by some editors and magazines with articles and editorials saying that ten thousand private airplanes would be sold during the coming year. As a matter of fact, there probably were not a dozen.

Up until the year 1927 there was little progress, the large overstock of war materials and completed airplanes making unnecessary the manufacture of any number of new ones. But with that year the upgrade began. Lindbergh's flight to Paris caught the public's fancy, the romance and adventure of aviation appealed to them, and there was an increased interest in everything pertaining to aeronautics. The interest became so keen that it did not hold itself passive, but demanded expression in some form of action. Where actual flying was impossible, as it was with the great majority, and where no opportunity was open for making a connection with some aeronautical company, the action took the form of desire to invest in some company as being the next best thing. The record of public enthusiasm is clearly shown in those days by the prices at which the aeronautical stocks sold on the stock exchange. Prices were fixed primarily by the demand for pieces of paper which were limited in supply and which represented part ownership in an industry with a romantic appeal. Wright Aeronautical rose from nine to ten dollars, the price in early 1926, to around eighty at the time of Lindbergh's flight, and from there went to the equivalent of over three hundred in the last days of 1928. By equivalent is meant the selling price after taking into account the splitting up of the stock. Such a record clearly showed the public's interest in aviation and in aeronautical finance.

ANYTHING which the public was so eager to purchase naturally became of interest to brokers and underwriters, and as there were not enough stocks then listed on the exchange to fill the popular demand, pressure was brought to bear on all aeronautical concerns to secure additional capital by issuing common stocks. August and September of 1928 saw the beginning of a flood of aeronautical securities, many of which had little to do with any actual demand for capital. The money was literally forced upon the aviation companies. It is hard to get an accurate idea of exactly how much money was put into the industry during that period, but three hundred million would not be far from a good guess. That figure would not include airport companies or companies incidentally supplying aeronautical accessories, but only those whose business was primarily aviation. While this may seem to be quite a large amount of money, in comparison to such extensive industries as iron and steel, the investment is still small.

However, the prosperity of an industry cannot be judged by the amount of money which is put into it. To be prosperous there must be an adequate return upon the money invested. Investigations into the automobile industry and others somewhat similiar in character to the aviation industry, have shown that the annual profit runs around 16 per cent of the gross sales. For year in, year out returns, and in consideration of the risks, 8 per cent is not too high a return to expect upon money invested in aviation. Then profit equals 16 per cent of sales and profit equals 8 per cent of capital, which gives a two to one ratio. For an industry to be in a healthy condition, therefore, the annual sales must be ordinarily at least half of the value of the securities of the industry. The aviation industry at the present time is reaching hardly a third of this figure. In some cases, profits made in 1929 were only incidentally due to aeronautical work, for the large amount of capital which had been supplied the industry was more than could be used up entirely within itself, and frequently the excess was employed in the call money market and loaned at higher rates of interest. Many people who thought that when they were buying aviation stocks and that they were therefore getting into aviation were actually becoming partners in a money lending business with a good part of their capital.

(Continued on page 148)

The Seadrome

Floating islands will make feasible commercial air connections with other continents

By EDWARD R. ARMSTRONG
President
Armstrong Seadrome Development Company

TO appraise properly the value of the seadrome project as the only commercially feasible method of inaugurating and maintaining a reliable and safe ocean airway service between America and Europe a short résumé of the present status of other suggestions or proposals is given herewith, with an estimate of their future prospects of fruition in the light of past experience.

Atlantic airway proposals naturally divide into two classes — airplane routes and those to be operated by dirigibles. Since 1918 many airplane flights over the Atlantic have been attempted. But few have been successful. In no single instance can any of the completed flights be regarded as indicating in the remotest degree the possibility of establishing a safe and profitable air service between America and Europe with the facilities now available either in equipment or personnel. Today in 1930, eleven years after the first successful nonstop flight over the Atlantic, made by Capt. John Alcock and Lieut. Arthur W. Brown in a Vickers-Vimy bomber, there is nothing to indicate that the progress possible in the next eleven years, or succeeding years, will materially alter this outlook.

The French, who have been operating an airway from France, down the west coast of Africa, to Buenos Aires, South America, across the South Atlantic, for several years, still use steamships for the ocean crossing of about fourteen hundred miles, and recently it has been authoritively stated by the company operating the service that while they hope some day to make the whole trip by air, there was nothing to indicate how or when this would be possible.

In Germany, where Rohrbach, Junkers and Dornier have spent millions in attempts to build long range airplanes designed ultimately for trans-Atlantic service, they have not been able to appreciably increase the useful load per horse power even in their largest planes, and have, according to recent press announcements, abandoned their tentative proposal for South Atlantic air service until more advanced equipment and methods are available.

DIRIGIBLES of the rigid type have been, and still are, seriously proposed as offering the only solution to ocean airways. The most recent example of commercial dirigibles, the R-100 and R-101, just completed by the British Government at the cost of approximately seven million dollars, have been declared by their principal sponsor and designer, Sir Dennis Burney, impractical commercial ships, valuable only as experiments. The R-101 is now being cut in two and lengthened in an attempt to improve its performance.

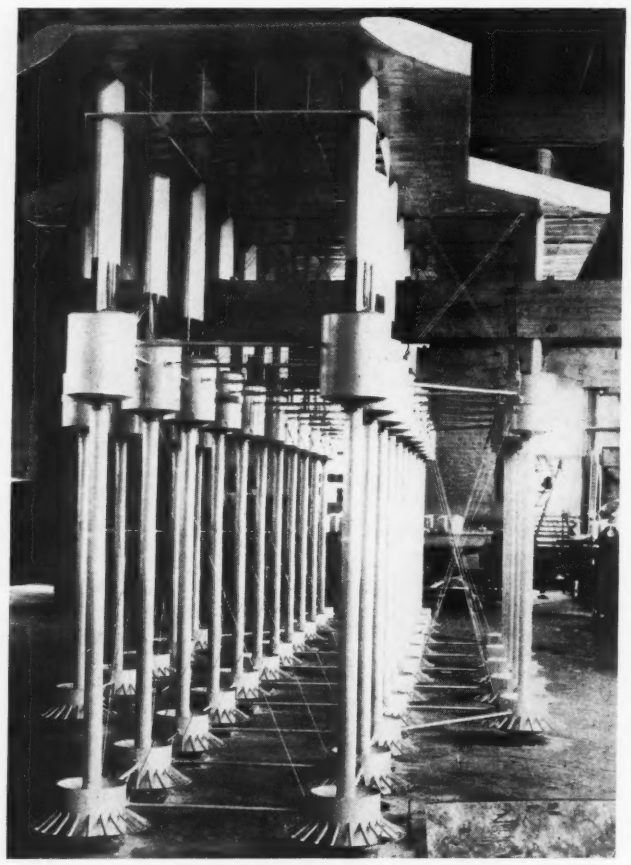
The Graf Zeppelin, certainly the most successful of post-war airships, is not, according to her commander, Dr. Eckener, large enough or fast enough to be other than an experimental development. Many millions will have to be spent and several years of experimental operation elapse before any definite conclusion can be arrived at as to the commercial possibilities of dirigibles.

Whether or not they are eventually successful has very little bearing on the seadrome development, because the investment and operating cost of the seadrome airplane service between America and Europe will always be quite materially lower than even the most optimistic estimates made covering the corresponding dirigible service. In addition, due to fundamental differences between airplanes and dirigibles, the speed of the airplane route will be double that of the dirigible with a frequency and variety of service easily ten times as great.

While there are no definite trans-Atlantic proposals, other than the seadrome system, looking towards trans-Atlantic airways, it has frequently been suggested that an airplane route might be feasible over the North Atlantic, by way of Labrador and Newfoundland, to Greenland, Iceland and so on to Europe. Experimental trials of this route, both east and west, made during 1929, resulted in total failure and the announcement, by the backers of the experiments, that even at the best season of the year this northern route would be entirely impractical, commercially.

The southern route, westerly over the ocean, from Portugal, or Spain, to the Azores, thence to Bermuda and on to America, has also been frequently suggested and quite a number of attempts made to fly to America by this route. In every instance, however, failure has resulted.

Ten years of progress in airplane design and operation has not reduced the hazard of ocean flying appreciably. It is still a death defying stunt, and without the aid of seadromes, will long continue to be extremely hazardous with no prospect of ever being a certain and safe commercial operation. In summation it can be very definitely stated that other than the seadrome proposal there is no project for an ocean airway between the United States and Europe, and it does not appear that a sound commercial venture reli-



SEADROME MODEL

This model, $\frac{1}{32}$ full size, has successfully withstood a fifty-mile-per-hour wind, accompanied by four-foot waves. For the full-size structure, this would be the equivalent of a wind of 280 miles per hour and waves 144 feet high.

able and safe in operation is possible now, or can be forecasted as being possible, at any reasonable definite time in the future. It further has been definitely established that "if and when and as" such services are in operation they could not compete with the seadrome system, using the same advanced equipment that now appears necessary to make any other project possible.

The world-wide interest in the seadrome development is sufficient insurance that it is not enthusiasm running wild that has led to the above conclusion. The technical, business and political aspect has been studied in considerable detail abroad and has been the subject of official comment by the Governments of the United States, England, France, Germany, Italy and Japan.

THE final form of the seadrome is the evolution resulting from fifteen years of investigation, design and test. Beginning with the first design made in 1915, about twenty different types have been made the subject of experiment and study. The basic structure represented in the present design was originated in 1919 and as finally worked out, follows very closely the fundamental principles incorporated in the first model constructed in 1922.

Subsequent tests have but confirmed the basic principle of the structure as being the only feasible way of building a floating station suitable for ocean airport service. There seems therefore ample justification for the widely held opinion that no other type of structure will successfully serve the purpose and survive under the weather conditions associated with the service.

The seadrome deck, of steel, 70 feet above sea level is 1,100 feet long, 340 feet wide in the central zone and 180 feet wide at the ends. It is supported by 32 buoyancy tanks, connected to the deck by means of streamlined iron columns, the whole forming a deep truss by means of tubular struts and steel cable ties. The buoyancy tanks are arranged symmetrically in four rows, the outer row being composed of five tanks, 34 feet in diameter, and the central rows of 11 tanks each, 27 feet in diameter. All tanks are 38 feet deep. The longitudinal spacing of the buoyancy tanks averages 100 feet. Below the buoyancy tanks the lower columns extend about 100 feet to support the ballast tanks, which contain iron-ore ballast sufficient in amount to bring the centre of gravity of the structure as a whole about 10 feet below the centre of buoyancy.

Due to the peculiar arrangement of its elements a seadrome does not roll, pitch or heave when exposed to wave action. Waves go through the open-work structure without being disturbed or their orbital movement of propagation broken up so that there is no release of energy from the wave system and therefore practically no stresses produced in the seadrome when it encounters the maximum in waves associated with the most severe storms possible at sea.

ALL the exposed parts of the seadrome in the region of the water line, and above, are of streamlined shape to reduce wind resistance to a minimum. The lower column system is made amply strong so as to avoid the need of struts and ties, which would greatly increase the water current resistance as well as introduce considerable complication in erection and maintenance.

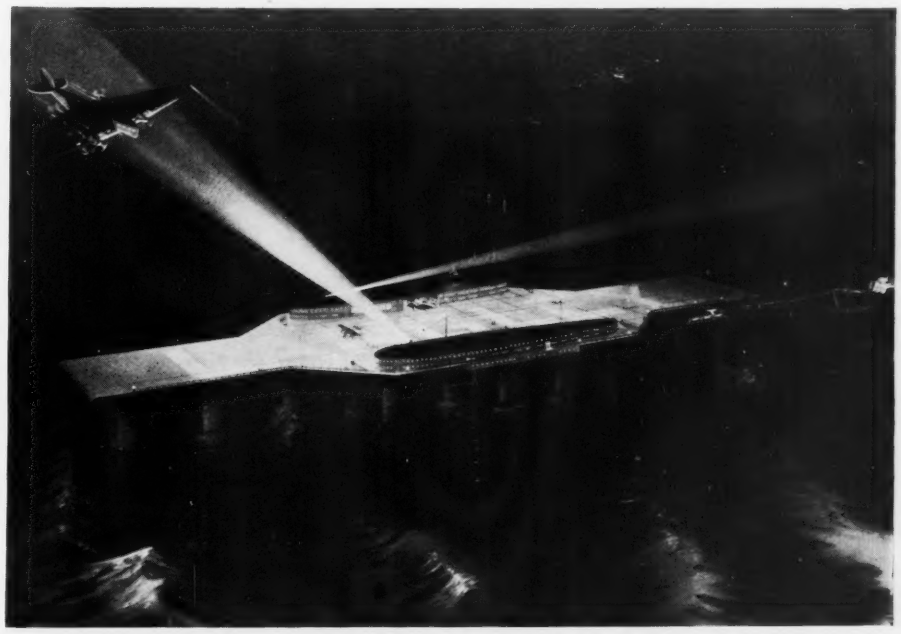
The deep sea draft of the seadrome, on station duty, is 177 feet. Obviously such a great draft precludes erection close to shore so special construction is adopted to permit this operation in shallow water, with a draft of approximately 44 feet. The ballast tank columns are designed to telescope up inside the streamlined upper columns, connecting the buoyancy tanks with the deck, the ballast, ballast tanks and ballast tank columns under this condition being supported by the buoyancy of the ballast tanks.

The structural weight, as finally worked out, exceeds that estimated in the preliminary design, the total now being about 17,500 tons. In general the deck system has been designed by structural steel and bridge engineers, in accordance with the specifications of the American Institute of Steel Construction. The buoyancy system, designed by naval architects and shipbuilders, is according to American Bureau of Shipping and Lloyds requirements. Soft steel is the principal construction material, used with riveted joints, the single exception being the deck plates which are welded. Special rivets are specified in all situations directly exposed to sea water, to minimize corrosion brought about by electrolytic action.

Decks and bulkheads divide the buoyancy tanks into seven water-tight compartments, a total for the whole structure of 224 subdivisions, believed ample from a safety point of view to insure adequate buoyancy under all conditions at sea. An electrically-driven bilge pump is provided in each buoyancy tank, so connected as to drain seepage water from any compartment. Provision is also made to use compressed air to clear any compartment of water, should it be necessary. Either the bilge pump or the air system is used to maintain the desired water-line displacement and trim. Any compartment is accessible for maintenance and repair from the inside, special paints being ordinarily used to inhibit corrosion.

The streamlined columns, connecting the deck with the buoyancy tanks, are made of iron because investigation has shown that iron is very resistant to corrosion by salt water. The record of longevity of iron sailing ships establishes beyond question that iron, for all practical purposes, will last indefinitely in sea water. According to Lloyds Register of Shipping there is a total of 162 iron sailing ships still in commis-

(*Continued on page 150*)



ARTIST'S CONCEPTION OF THE STRUCTURE

Ample hangar space and hotel facilities are provided. The deck will be 1,100 feet long, and will have a maximum width of 340 feet. It will not roll or pitch in any weather.

CONTRASTING THE PROPOSED NAVY AIRSHIP WITH A BATTLESHIP

This new airship will have a capacity of 6,500,000 cubic feet, and will be inflated with helium. It will have an overall length of 785 feet, and a useful lift of 193,000 pounds.

Lighter-Than-Air Craft

Recent developments have given an impetus to this industry

By PAUL G. WILSON
Publications Department, Goodyear Zeppelin Corporation

SEVERAL important developments recently have given considerable impetus to the growth of the lighter-than-air craft industry. Chief among these developments were (a) the first experiments with a commercial trans-atlantic air-service by means of the rigid airship Graf Zeppelin; (b) authorization by the United States Navy Department for the construction of two rigid airships of 6,500,000 cubic feet capacity by the Goodyear-Zeppelin Corp.; (c) development and construction by the British of two 5,000,000 cubic feet airships to be used for long-distance passenger and mail transportation; and (d) erection of the world's largest airship factory and dock by the Goodyear-Zeppelin Corp. in Akron, Ohio; and construction by the same company of a fleet of small non-rigid airships to be used for commercial purposes.

ALTHOUGH all investigations had indicated that a 5,000,000 cubic feet hydrogen ship was the smallest that was practical for the proposed service, the German Zeppelin company found itself limited as to size and fineness ratio by the size of the available construction hangar. Therefore the hydrogen capacity of the Graf Zeppelin was made 3,710,000 cubic feet; the length, 770 feet; and the diameter, 100 feet. Propulsion is by five 530-h. p. engines, a total of 2,650 h. p., giving a top speed of 78 m.p.h.

At this speed the cruising radius is about 5,360 miles, while at a cruising speed of 70 m.p.h. the range is increased to 7,030 miles. These figures apply to the ship carrying 20 passengers and 5 tons of freight in addition to a crew of 40. In fundamental design this ship follows in general the conventional principles embodied in its immediate predecessor, the Los Angeles.

One novel feature incorporated into this new ship must be considered as a definite step in the proper direction. This is the adoption of gaseous fuel. Previous ships, flying with liquid fuels, grew lighter during flight as the fuel was consumed and therefore had to valve out some of the lifting gas to re-establish equilibrium; for instance, to land after a long flight. The designers of the Graf Zeppelin selected a fuel gas having the same density as air so that the consumption of fuel would not lighten the weight of the ship. The ship is, therefore, always in static equilibrium, and the valving of hydrogen is not necessary.

It had also been the practice in previous ships to retain the lifting gas within cylindrical cells which, when fully inflated, completely fill the hull. But in the Graf Zeppelin the lower third of the hull volume has been given over to an additional set of cells in which the fuel gas is carried. The lifting-gas cells occupy the available hull space above the fuel-gas cells.

SEVERAL important lessons can be learned from these flights. It is evident that even airships built along conventional lines are capable of withstanding abnormal weather conditions. It seems imperative, however, that if regular service is to be maintained ships must have higher speeds; and, since a fast and regular service will not permit the circumnavigation of any but the worst storms, it is advisable that they be built more rugged and compact, to withstand the strain from repeated stresses that may be encountered in the gusts of heavy gales. The Graf Zeppelin demonstrated that such passenger accommodations as she has are not quite as commodious or comfortable as the ocean traveling public would expect on regular lines.

It is extremely fortunate that the United States Navy, in its recent order

(*Continued on page 152*)

Commercial Airline Operation

An outline of the economic problems involved in the operation of an airline

By FRED GOODCELL
Direction of Public Relations
Western Air Express

PROBLEMS faced by airplane operators in the United States have been similar to those met, and conquered, by the older surface transport systems; in some instances they have been more complex.

The popular conception is that the airplane as a transport machine is much more common in several European countries than it is in the United States. Records will show, however, that American airplanes engaged in transport cover more miles daily than those of any other nation in the world. They have been operated with a reliability record unexcelled by any other nation. They have carried more mail and thus been of greater service to the greatest number of people than the airplanes of any other nation. And, barring the subsidies granted by all foreign governments to their air transport companies, they have been operated with unequalled financial success.

SOME of these problems have been faced by the older transport concerns, but not all of them. The steamship was ridiculed at first, but great cities built harbors for them and transportation of passengers and goods by water was encouraged.

The steam train had its problems, including the perfecting of steel rails that would stand the constant pounding of locomotives and heavy cars. But the early railroads were encouraged by valuable government grants and they never considered such things as weather reports or radio equipment.

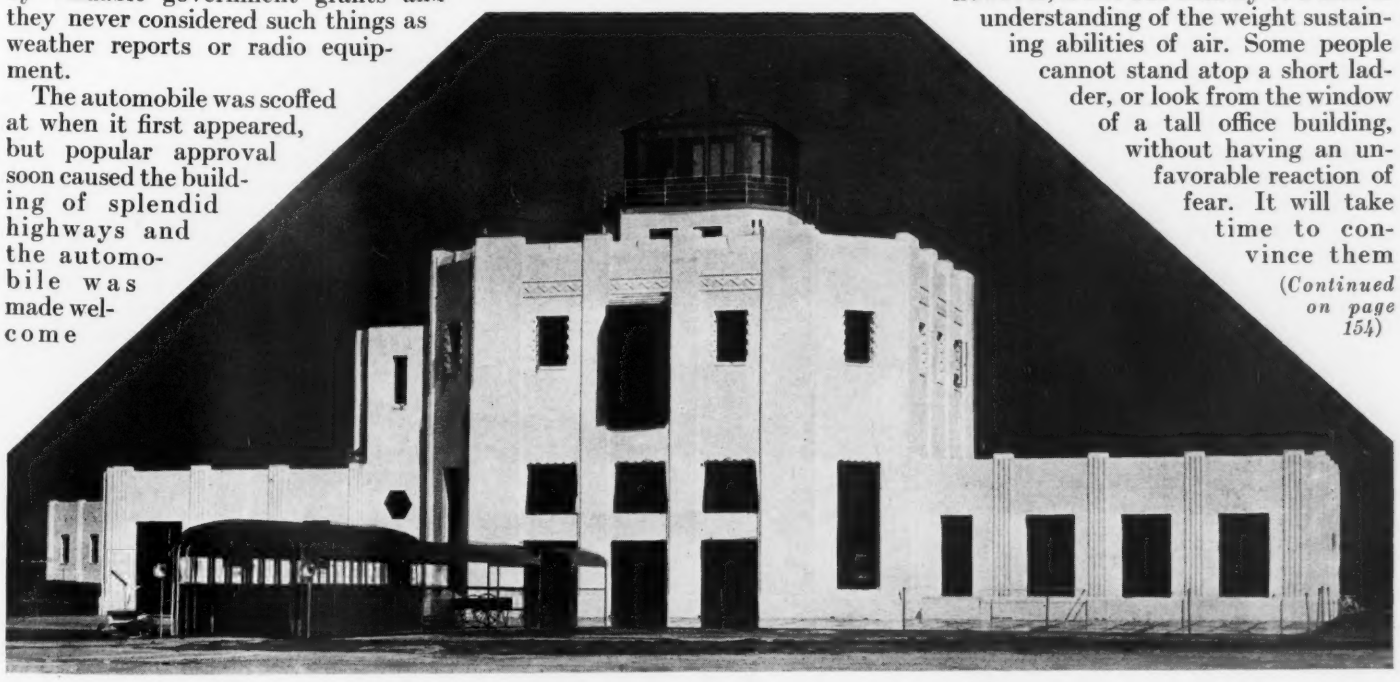
The automobile was scoffed at when it first appeared, but popular approval soon caused the building of splendid highways and the automobile was made welcome everywhere. Of course, there was no thought of weather reports or radio and navigation instruments included a speedometer and perhaps an oil gauge.

The airplane since its advent as a transport machine has been generously aided by our Federal Government, by numerous municipalities and by many organizations and individuals. But what has been done for air travel is insignificant in comparison to what has been done for the other and older carriers. Billions of dollars have been expended out of the public purse for the construction of wharves and docks, the deepening of harbors and rivers, the building of canals and the establishing of lighthouses. Many billions have been granted our railroads in the shape of rights-of-way and still more billions have been expended in highway construction to aid automobile use. Until the last two years, however, there was hesitancy on the part of our municipalities to aid the airplane. The Federal Government had done much and is still giving the air transport companies splendid coöperation, but more needs to be done, particularly in the way of establishing airports. Now, fortunately for the progress of air transport, our more progressive cities have awakened to the possibilities of the airplane as a carrier and they have realized, too, that they can establish an airport and operate it at a financial profit. The result is that there are now approximately 1,500 airports and landing fields recognized by the Department of Commerce and an equal number of airports are under construction or being planned.

With the advent of every new transport machine there has been a certain amount of educational work to overcome the timidity of some people. Man is not essentially a bold animal. He is, in fact, overly cautious. Our people have feared to ride upon boats, upon trains and in automobiles. It has taken time and patience to overcome this fear. The same has been true with the airplane, but our problem has been somewhat more complex than that faced by other carriers. It has been natural for mankind to look upon land as something to walk upon, or ride upon, and for many centuries boats have been plying our seas and rivers. Too few people have stopped to realize that air also has weight sustaining power, that like water it also may be considered as a fluid and that if it can hold a bird aloft in flight it can likewise hold aloft a man-made machine possessing similar wings, or sustaining surfaces, plus the needed propulsion power.

The inherent fear of being in the air, however, is not due entirely to a lack of understanding of the weight sustaining abilities of air. Some people cannot stand atop a short ladder, or look from the window of a tall office building, without having an unfavorable reaction of fear. It will take time to convince them

(*Continued on page 154*)



PASSENGER DEPOT NEAR ALHAMBRA, CALIFORNIA
Airplanes of the Western Air Express Company arrive from and depart daily for various points in the West.

The Zeiss Planetarium

This device simplifies the teaching of astronomy

By Alfred B. Berghell '32

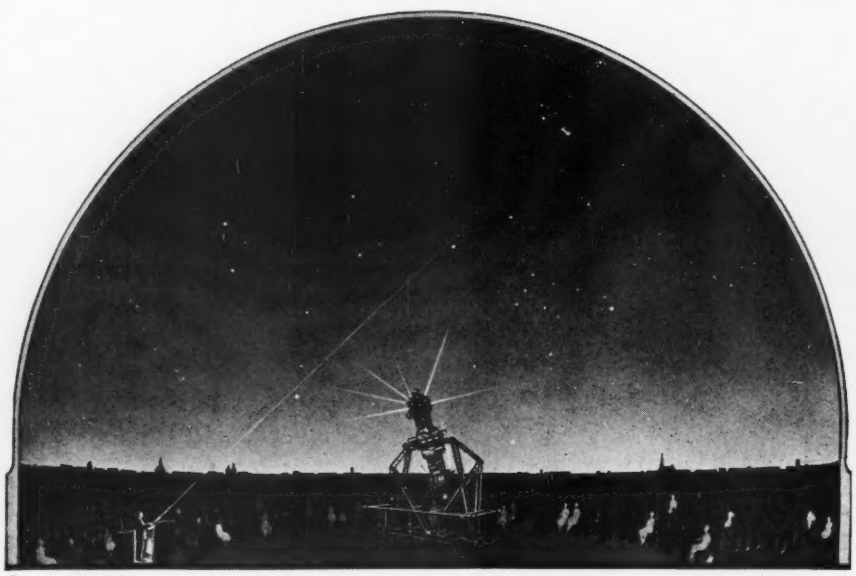
ASTRONOMY, because of the complexity of the subject, has been one of the things which it has always been difficult to teach. In the past, in order to explain the movements of the planets around the sun, attempts have been made with varying degrees of success to build mechanical models. One of the first of these was one constructed by Charles Boyle, fourth Earl of Orrery (1616–1731), who built a very complex model in which the planets were represented by spheres of various sizes supported on a movable framework and driven along their paths by mechanical means. Although this type of model did have merit in helping to explain the workings of the heavenly bodies, it had the demerits of having the mechanical parts very much in evidence, which destroyed the effect and was very cumbersome and extremely difficult to build showing many of the heavenly bodies.

The Zeiss Planetarium is built upon an entirely different principle. Instead of the observer being placed in a position in outer space, he is on the interior of a large hemisphere made to represent the heavens, his position being similar to that of an observer upon the earth's surface. Instead of using mechanical models of the stars and planets, representations of them are projected from the large Planetarium instrument placed in the center of the floor. This instrument consists of two semi-spherical star-image carriers, one for the southern and the other for the northern hemisphere, placed at opposite ends of the instrument. Between these carriers is a section of the cylindrical framework for projecting the bodies of the solar system. Lenses and light sources, together with film in some cases, provide the means of projecting the images of the heavenly bodies upon the large dome of the Planetarium. The apparatus which thus throws lantern slide images of stars upon the dome is very complex, 119 optical projectors being required to reproduce every possible motion in a celestial body. There are 16 for the fixed stars of the northern sky; 16 for the fixed stars of the southern sky; 18 for the nebulae, star clusters, and Sirius; 10 for the Sun, Moon, and Saturn; 8 for Mars and Jupiter; 12 for a network of lines which includes the zodiac, the polar circles, and the ecliptic; and others to indicate names and to serve various additional purposes. Besides these there are three electric motors alone for controlling the length of the year, while others mimic the nutation of the earth and vary geographical latitude.

ONE can imagine the complexity of this instrument when it is realized that in its final form every single star which on a clear night is visible to the unaided eye is so accurately shown within so close a distance of its actual relative position on the dome, that it would be necessary to take actual astronomical observations by means of instruments to reveal any error. Through nearly 9,000 stars, the sun, the moon, and the planets move along paths which are so nearly correct that the maximum possible deviation in the orbit of any one of the planets for a period corresponding to 5,000 years would be only one degree. One of the chief values of such an artificial representation of the heavens is the manner in which events which take place in nature with extreme slowness can be speeded up so that instead they can be made to take place within a very few hours, minutes, or seconds. Thus it is possible to show the diurnal movement, by which the heavens once in every twenty-four hours appear to revolve about the earth, within a period of four minutes or in one and one-quarter minutes. For studying the motions of the planets, a whole year may be made to take place in four minutes, in one and one-quarter minutes, or in seven and one-half seconds. It is possible to speed up events still further so as to show the heavenly vault as it will appear ten or twenty thousand years from now, at which time it will be rotating about a different pole star. A quick precession drive allows this to be done carrying the pole of the heavens once around its 26,000-year cycle in one and one-half minutes.

Not only is it possible to change the time in which events take place in the heavens, but it is also possible to show the spectator how the heavens would appear to stargazers on other parts of the earth's surface. They can be transported to the tropics and shown constellations which they have never seen, or they can be taken to either pole where the celestial bodies simply swing around forever in circles without rising or setting. Thus it can be seen that in a modern Planetarium any star can be shown as it appears at any time from any part of the earth.

IN reproducing the Milky-Way, more trouble was experienced than in the entire problem of fixed-star projection, due to the difficulty in finding a type of image which was satisfactory. The Milky-Way is composed of areas which have varying degrees of light intensities and in order to get a true representation these had to be faithfully reproduced. A reproduction of one-half the Milky-Way film used in the projector is shown in one of the illustrations. This image was made in accordance with a special map obtained from an astronomical observatory, and shows clearly the varying degrees of light intensity. A careful examination will show the fine network to be made up of a large number of irregular fields of equidistant white spots which are



Courtesy Carl Zeiss

CROSS SECTIONAL VIEW OF THE INTERIOR OF THE PLANETARIUM

The lecturer is pointing out the stars and planets by means of a flashlight.

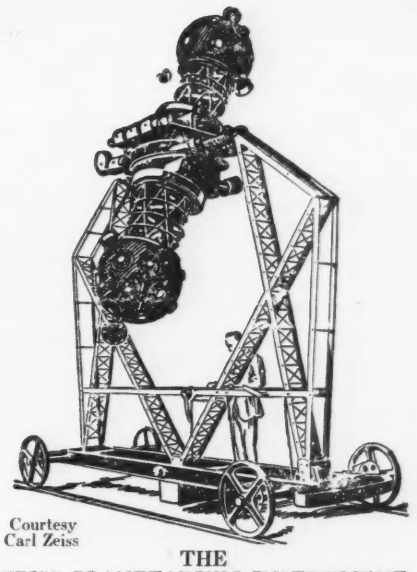
arranged upon a curvilinear pattern in order to prevent refraction effects, such as would arise from a rectilinear pattern, like that of the screen of a half tone engraving. The two points marked "Canopus" and "Coronae Austrinae" are the names of stars used in locating points for adjusting the position of the image with reference to the field of stars.

In reproducing the Milky-Way a pattern of dots was arranged on concentric circles laid out by draftsmen on a large scale. This same pattern was then repeated ten times, each time using dots of a larger size, thus giving ten patterns of as many graduated degrees of "darkness." Negative prints made on a reduced scale were then made from each pattern, these prints showing white spots on a black background, in ten different degrees of "lightness." By cutting out sections of the required shape from a number of such prints and pasting them together on a board in an arrangement corresponding to the map, an accurate large scale original was obtained. All that was then needed was a photographic reduction to the proper size to yield the film.

THE Planetarium instrument is controlled by a lecturer. A spectator takes his seat beneath the dome with six hundred others. As the lights are gradually turned down, the white ceiling above loses its whiteness and his eyes become gradually accustomed to the darkness. When a switch is thrown, the vault becomes studded with stars, and he finds himself out of doors, beneath a firmament of twinkling stars. The lecturer controls the instrument from his desk and points out the various stars and planets to the spectators with the aid of a flashlight which flashes an arrow on the dome. He shows them why Venus appears only as a morning or as an evening star, and is never seen at midnight because Venus circles around the sun within the orbit of the earth. Dr. Bauerfeld, the engineer who designed the Planetarium, has succeeded so well that the effects correspond exactly with those of nature. The heavens within the Planetarium appear a faint blue, the same phenomenon which is observed out of doors on a clear night. Care has been taken that as a star sets, it becomes fainter, even as it does in reality, due to the thicker layer of air through which its light must pass.

In building the structure of the dome itself for the Munich Planetarium, the attempt was made to have it made with the least possible expenditure for material and wages. A network dome was constructed of iron rods of varying lengths joined together by means of girderlocks. When the network was completed, the inner surface was covered with a temporary wooden sheathing, against which concrete was sprayed. For insulation purposes cork sheets were used to cover the dome, and over these rubber sheets for roof covering. For the Munich instrument the entire thickness of the finished dome covering, including the insulating layer, is only 1–250th part of the dome's diameter. The ratio of the thickness of the shell of the dome to its diameter is therefore less than that of the eggshell to the diameter of a hen's egg.

However, a concrete lined dome has very poor acoustical properties due to sound waves from the speaker being reflected from the hard walls, and because of the shape of the dome coming to a focus again, after the lapse of a short time interval. To remedy that in later constructions, an inner dome was constructed inside of the outer concrete one, and this inner one was covered with white linen which allowed the sound waves to pass through it easily. Between the two domes were placed a large number of thin metal plates, set at varying angles so that the sound waves passing through were diverted in different directions, and did not come to a focus again. In this manner the acoustics were improved and disturbing echos were eliminated.



Courtesy Carl Zeiss

THE ZEISS PLANETARIUM INSTRUMENT

It projects the images of the stars and planets upon the Planetarium dome.

Courtesy of Henry Simon and *American Machinist*

ONE-HALF OF THE MILKY-WAY FILM

The white dot at the upper right is "Alpha Coronae Austrinae," one of the two points used to denote the positions of stars for locating the projected image with reference to the field of stars shown on the screen.

The Diesel Aircraft Engine

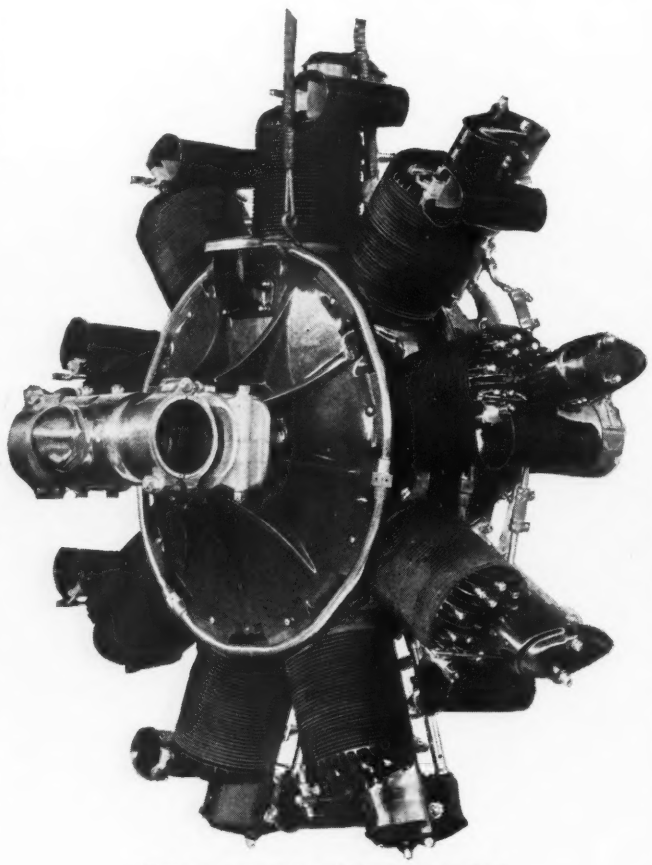
A few of the design features incorporated in the new Packard power plant

By CAPTAIN L. M. WOOLSON
Aeronautical Engineer, Packard Motor Car Co.

THE most interesting aspect of the engine design is undoubtedly a consideration of the design features which have brought the weight of the Packard Diesel engine down to practically the same level as that of gasoline aircraft engines of equivalent power. Heretofore Diesel engines even of the so-called light weight modern type have weighed around 25 pounds per horse power, whereas the Packard engine weighs but one-tenth as much.

A review of the design will show that important weight economies have been secured by, first, the elimination of carburetors and magnetos, and secondly, by an intense simplification of design. Evidences of the latter are found in the one-piece crankcase construction of extremely light weight and the single valve arrangement which automatically halves the number of parts required for valve operation as found in conventional gasoline engines.

THE crankcase which weighs only 34 pounds is unique not only because it is of one piece, thus dispensing with heavy flanges and bolts, but also in respect to the novel fashion in which the cylinders are fastened to the crankcase. Ordinarily in a radial air-cooled aircraft engine each cylinder is held to the crankcase by a multiplicity of studs screwed into the crankcase flange and projecting through the cylinder flange against which the retaining nuts seat. With this arrangement the tension stresses resulting from the explosion loads in the cylinders are carried through the crankcase walls to the crankshaft main bearing anchorage. This involves fairly heavy crankcase construction even with a gasoline engine but such structure applied to the Diesel principle would require the use of very thick sections since the light alloys used in crankcase construction have poor resistance properties for this type of shock loading. In the Packard engine two circular hoops of alloy steel encircle the cylinder flanges in contact with the crankcase at the front and rear of the engine and these hoops are contracted by means of sturdy turnbuckles so that an initial stress is set up in these hoops which exceeds by a wide margin the operating stress resulting from the cylinder explosions. Under this system the crankcase is subjected to an initial compression which it is well adapted to resist. However, when the engine is running these stresses are materially reduced and at no time is it possible to transfer any tension loads from the cylinder to the crankcase.



THE PACKARD DIESEL ENGINE
A quarterly front showing the engine ready for the installation of exhaust manifold and propeller blades.

Although the analogy is not strictly correct, a comparison may be made with an automobile wood wheel representing conventional aircraft engine crankcase construction on the one hand and a wire wheel representing the new Packard crankcase arrangement on the other hand. The latter construction has proven considerably lighter because the load is not transferred from the ground to the hub directly through the lower spokes as is the case with the wood wheel but is spread over a great many more spokes arranged in the upper quadrant of the wheel. Those spokes in a wire wheel which are directly above the ground receive no load at all but rather have their initial tension reduced just as in the Packard crankcase that section of the crankcase immediately below the working cylinder has its loads reduced rather than increased at the time of explosion.

EQUAL in importance to the crankcase construction, which permits a light structure withstanding extremely heavy loads, are the arrangements whereby the crankshaft and propeller are protected from excessively high stresses.

In the Packard Diesel engine the maximum cylinder pressures are over ten times as great as the average cylinder pressures during the working stroke and this would necessitate the pistons, connecting rods, crankshaft and propeller being approximately ten times as strong as they would have to be to resist the average pressure were it not for the fact that effective measures have been taken to cushion these major parts of the engine from the shock-loading resulting from the high explosion pressures. Advantage is taken of the fact that these peak explosion pressures exist for a very short time in each cycle. The crankshaft counterweights and the propeller are both flexibly mounted on the crankshaft so that when the peak pressures occur a cushion is interposed between the crankshaft and those parts which have the maximum inertia or flywheel effect. In this manner the stresses in the crankshaft are greatly reduced and it is possible to use a crankshaft of a size not substantially different from that employed in a corresponding gasoline engine.

To describe the cushioning methods in detail, the counterweights instead of being rigidly bolted to the crank cheeks are pivoted on them and are located between powerful compression springs. With this arrangement when the crankshaft is suddenly accelerated the counterweights lag behind slightly so that the peak cylinder pressure is expended before the counterweights are again solidly driven by the crankshaft. In a similar fashion the propeller

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Meteorological Research

The solution of meteorological problems requires men trained in mathematics and physics

By CARL-GUSTAF ROSSBY
Associate Professor of Meteorology
Massachusetts Institute of Technology

IT would perhaps have been natural to stress in the following lines the need of a well organized meteorological service for the commercial and military airways of the country. At the present time, however, this need is so generally recognized, even though individual conceptions of a satisfactory meteorological service may vary, that little or no good would be accomplished by such an article. Instead, I have attempted to discuss a purely meteorological research problem, the ultimate solution of which should be of definite value to aeronautics.

It seems to me that the pursuit of meteorology should be encouraged because it adds to our knowledge of the nature in which we live. To justify the study of the atmosphere by pointing to the practical value of the results is in my opinion to degrade the science. It is also an impractical attitude since work conducted in such a spirit rarely produces fundamental results. My aim is to show that research without side glances to the gallery is stimulating and productive of far-reaching results and that the practical applications often may be had for the picking. The study of atmospheric turbulence furnishes good illustration in point.

A CASUAL inspection of a few wind structure records will show that the wind velocity generally exhibits rapid, irregular fluctuations (20-25 per minute), the average amplitude of which variations roughly may be said to be equal to the mean wind velocity itself. These fluctuations indicate that the air flow is of a turbulent, eddying character.

In attempting to visualize the effects of this eddying motion, meteorologists usually assume that small bodies of air at frequent but irregular intervals are pushed away from their original positions into other strata, where they are gradually absorbed by the surroundings. These small bodies of air, "turbulence elements" in meteorological parlance, may be compared with the molecules of the kinetic theory of gases. The distance covered by an element before absorption then corresponds to the free path of the molecules. The significance of these travelling eddies lies in the fact that they carry the properties of their "mother layer" into the new surroundings. Thus, they cause a diffusion of various atmospheric properties, which will increase with the number and magnitude of the eddies themselves. Most characteristics of the atmosphere (for instance, temperature, humidity, wind velocity) vary slightly or not at all in a horizontal plane and the effect of the horizontal displacement of the eddies is therefore negligible. In vertical directions, however, conditions are more rapidly variable. The specific humidity, or the atmospheric water vapour content expressed in weight percentage, usually decreases fairly rapidly with elevation. It is easy to see that a vertical exchange of eddies will lead to a net transport of water vapour from moist to dry strata, in other words, upward. This transport will depend upon two factors, a coefficient A measuring the intensity of the mass (eddy) exchange through a horizontal surface and a factor measuring the rate of decrease of specific humidity with elevation. Thus there is a general upward transport of water in the atmosphere from the surface of the earth where the supply is replenished through evaporation to the cloud level where condensation and precipitation take place, completing the circulation.

The same principle may be applied to the transport of wind velocity (horizontal momentum). It is obvious that a constant transport of velocity will take place from rapidly moving to slower moving strata of the air, thus tending to equalize the differences in velocity between various layers. The expression for this transport of momentum is similar to the one obtained for the transport of moisture. It is then easily seen that the quantity A introduced above may be interpreted as a fictitious viscosity coefficient caused by the haphazard movements of the eddies.

If the state of turbulence is known, in other words if we know the value of A, it is easy to calculate the effect of the eddy motion upon the variation of various meteorological properties with elevation. In this way a satisfactory theory for the variation of wind direction and wind velocity with elevation has been developed, the opposite phases of the diurnal variation of the wind velocity at the ground and at some elevation above the ground have been explained, the transmission of the diurnal variation in temperature at the ground to higher levels has been investigated and also a series of other phenomena, too numerous to mention here.

THE theory sketched above is based upon a very primitive picture of the movements of atmospheric eddies. At a fairly early stage the question therefore was asked, what are the factors controlling the number, magnitude and movement of the eddies? A complete answer to this question would enable us to calculate the state of turbulence and in particular the value of the quantity A from the observed characteristics of the atmosphere, whereas previous investigations have been based entirely upon suitable empirical values for A. The complete answer to this question has not yet been found.

It is known that the irregular (eddy) velocity fluctuations increase with the wind velocity and we know that they increase with the roughness of the ground.

In small scale studies of the flow of air or water it is well known that the change from laminar to turbulent flow takes place at a velocity determined from the critical Reynold's number. A similar critical velocity seems to exist also in the atmosphere. Wind structure records generally indicate that the airflow is fairly smooth and regular for mean wind velocities below six to eight miles per hour. As the mean velocity passes this value, the flow changes rather abruptly into one of marked turbulence.

HOWEVER, a comparison between laboratory results and free flow in the atmosphere is complicated by the effect of compressibility and buoyancy on atmospheric turbulence. In a turbulent stream of water through a pipe, an element displaced in any fashion will always be in hydrostatic equilibrium with the surroundings. In the atmosphere, if the element is displaced upward, it may, due to the change in pressure, arrive at its destination considerably colder than the surroundings. In such case the atmosphere exerts a damping effect upon the eddy motion and tends to prevent its full development. This stable arrangement of the atmosphere is characteristic of the winter season, the night, and northerly latitudes, when the lower strata of the air have been cooled through radiation. In other cases the ascending eddy will

(*Continued on page 170*)

The Construction of an All-Metal Flying-Boat

In this article are discussed some features of the Consolidated "Commodore"

By G. Garner Green
and
F. R. Shanley
Consolidated Aircraft Corporation

THE CONSOLIDATED "COMMODORE" IN FLIGHT

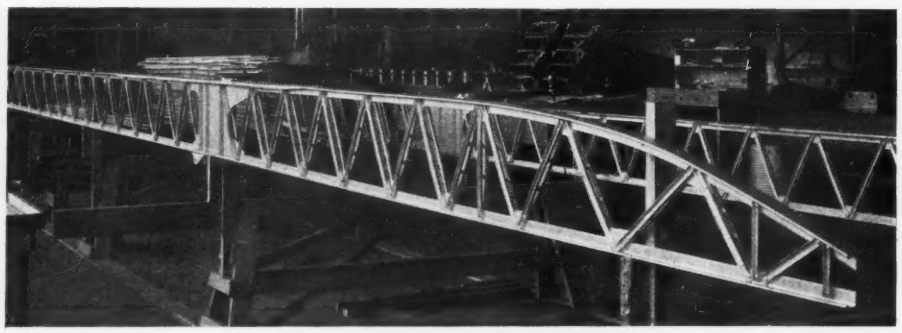
IN a flying boat of this type it is impossible to consider the structure as a whole: the hull is entirely separate from the wing and it represents a totally different problem in design. However, there are several interesting features to be noted in connection with the general design. The first of these is the all-metal construction, which is used for all of the structure excepting the covering of the wing and control surfaces, which is of fabric. Practically all of the structural material is duralumin, either in sheet or extruded form. Chrome-molybdenum steel is used for most of the important fittings, for parts subjected to vibration, and for some of the highly stressed struts. Heat treatment is used on both duralumin and steel parts in order to utilize the maximum strength of these materials.

The hull itself is 58 feet, 6¼ inches in length. At stations about one-half and three-quarters of the distance back from the bow, the bottom is broken by steps; the front step is the conventional type, consisting of an upward offset in the bottom lines of about four inches; the rear step is formed by curving in the side plating below the chine until the sides meet at the step. The maximum beam of the hull is 101 inches; the greatest depth from deck line to keel is 82½ inches. Over the pilot's cockpit a small cabin is built up to form the windshield and to enclose the pilot's compartment.

THE hull structure must serve two purposes: it must act as a sort of monocoque fuselage and must also serve as a boat structure. In the first case the forces due to the weight of the hull and its contents must be carried through the various members into the wing struts, from which comes the supporting force. Since these struts are attached at bulkheads 3 and 4, the whole structure can be considered as a sort of beam supported at these points and loaded at the various bulkheads. Under these conditions, the loads are carried into the keel members by means of the floor structure and from there into the bulkheads. The longitudinal stiffeners, in addition to taking their share of the tension and compression loads induced by the bending moment on the hull, serve to keep the skin from buckling or failing under the shear stresses imposed on it. They are themselves held in place and strengthened by the belt frames, which are not directly attached to the skin at any point.

In riding heavy seas, conditions are to be encountered in which the hull is supported by the wave crests, either at the center or near the two ends. These floating conditions are used in the analysis for ship hulls, but the "Commodore" is the first commercial flying boat in which the hull design has included a detailed analysis of these conditions. This analysis was first made by Mr. Roy A. Miller for the "XPY-1" flying boat, the Navy patrol plane which was the forerunner of the "Commodore."

The construction of the floats resembles that of the hull in many respects. They are made with two watertight bulkheads, to which the attachment fittings are riveted. Beltframes are used to support the longitudinal members. Vertical and diagonal members on the center line form a truss having the full depth of the float. Handholes in the deck plating are provided with removable watertight covers. Each of the three watertight compartments can be drained by means of a plug screwed in at the lowest point on the bottom.



WING SPARS OF THE "COMMODORE"
The web system used is of the Warren truss type.

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The Round Hill Experiment Station

Originally equipped to study radio communication problems this station now includes a modern meteorological depot

By JULIUS A. STRATTON
Assistant Professor of Theory of Electricity and Magnetism
Massachusetts Institute of Technology

THE Round Hill estate of Colonel E. H. R. Green is located on the western shore of Buzzard's Bay, some ten miles south of the old whaling port of New Bedford. For a number of years previous to the association of the Massachusetts Institute of Technology with the work at Round Hill, Colonel Green had been actively interested in radio communication, and as early as 1896 he attempted to utilize the results of Marconi's transatlantic experiments for train dispatching. Receiving equipment was installed in two baggage cars of the Texas Midland Railroad, of which he was president, and a transmitter operated from Terrell, Texas. The metal-filings coherer of that day was scarcely adapted to moving trains, and so the experiments were not successful. Communication, however, was maintained for some time with nearby fixed points.

With the early experiments in radio telephony Colonel Green's interest was revived and he became a pioneer in the broadcasting of programs to a radio public. Station WMAF, "The Voice from Way down East," was familiar to many an early enthusiast. Desirous of obtaining the best possible programs for his audience, Colonel Green was soon confronted with the problem of bringing the proper musical talent to a place so remote as Round Hill. The feasibility of transmitting a program over telephone lines from a New York studio was carefully investigated and an arrangement made with the American Telephone and Telegraph Company whereby programs rendered for its station WEAF would be transmitted by wire to Round Hill and re-broadcast by WMAF. This plan was put into successful execution on July 1, 1923. Through this interest and encouragement some of the first work in chain broadcasting was accomplished.

A PART OF THE RESEARCH GROUP

Some of the first work in chain broadcasting was conducted here, station WMAF having been successfully connected with station WEAF in New York early in 1923.

THOSE familiar with the history of radio communication will recall that the credit for the most important progress in that art in recent years is due solely to the amateur experimenter. In the first years following the war the channels of commercial communication became rapidly overcrowded and legislation was enacted which relegated the amateur to a region where it was thought he could do no harm. It has subsequently been shown that the 200 meter band is probably the most unsuitable for communication in the entire radio spectrum. Forbidden to extend his transmission to longer wave lengths, the amateur's only refuge was in the virtually unexplored region below 200 meters. The astonishing results of his endeavors in that direction soon attracted the attention of the entire radio world with the consequence that the possibilities of inter-continental communication have been prodigiously increased.

Desirous of encouraging the amateur in every way possible, Colonel Green began to provide research facilities on his estate for qualified experimenters, and to this end he erected buildings to be used as shops and laboratories. It was this idea which finally ripened into a plan of serious scientific research. In the year 1926 an agreement of coöperation was entered into with the Massachusetts Institute of Technology according to which the Institute was to determine the research program and to supervise its execution. We shall see how from a modest beginning this plan has been developed until there is to be

(*Continued on page 162*)

INTERIOR OF THE RADIO STATION

Not only does this station afford excellent experimental facilities, but it also has provided a public service by keeping in touch with such expeditions as that of the Graf Zeppelin and Byrd's trip to the South Pole.

The New Electives in Aeronautical Engineering

How the department of aeronautical engineering trains men in specialized branches of the profession

By JOSEPH S. NEWELL '19
Assistant Professor of Aeronautical Structural Engineering
Massachusetts Institute of Technology

IN order to appreciate the electives recently introduced into the fourth year of the course in aeronautical engineering it is necessary to go back about five years, to the year 1925. It was at that time that the financial world began to consider the aeronautical industry as a potential field of importance to investors and to agitate for regulation of air commerce by suitable government agencies. The first apparent, and perhaps the most noteworthy, result of this interest was the Air Commerce Act of 1926, which gave to the Department of Commerce the power to regulate and to foster the use of aircraft in interstate commerce.

The Air Commerce Act afforded a method for regulating both aircraft and personnel so that reasonable assurance could be given to operators and to the general public that those hazards of flight due to the faulty equipment and incompetent personnel would be eliminated. The Department of Commerce, through its Aeronautics Branch, was enabled to set up definite standards of airworthiness for aircraft and their equipment, and for the operating personnel. Provision was also made for the lighting and marking of airways by the Department, and for assisting municipalities and others in the development of airports. In other words, provisions were made for the fostering of the airplane industry by the somewhat indirect but nevertheless desirable method of establishing standards of safety which would convince the general public that travel by air was no longer impracticable because of the hazards it entailed.

AS a consequence, funds were made available by a number of investors for the development and operation of a well-planned system of transport lines. Several such began operating late in 1926 or early in 1927 and, although they were not markedly successful if measured by their popularity as passenger carriers, most of them carried mails or perishable freight and so were able to justify their existence as transport media. To a more limited degree, funds were also invested in some of the smaller commercial aircraft companies and plans were made for expansion, not too ambitious expansion in most cases, of factories and facilities in the hope that the general public would take up flying to a greater extent during 1927 than it had in the previous years. The feeling throughout the aviation industry seemed to be that now that the public could be assured of safety in flight it would fly, but there was not in the early months of 1927 the excessive optimism which was so noticeable a short time later.

To provide for this expansion in the industry it was quite obvious that the services of more engineers and designers would be needed and it was at this time that the Institute modified its policy of conducting the course in aeronautical engineering as a graduate course and while still maintaining the graduate curriculum, established in the Department of Aeronautical Engineering a four-year course leading to the degree of Bachelor of Science. One man fulfilled the requirements of this new course and was graduated in 1927. There were but eight or ten candidates for the Bachelor's degree as of the Class of 1928, and everything was tending toward the consummation of the expected expansion in the demand, and in the supply, of aeronautical engineers. The demand was rather broad in its nature and covered everything from design and research to operations, so the course of training was made as general as was compatible with the development of men who could take an active part in the industry without further expensive schooling by their employers.

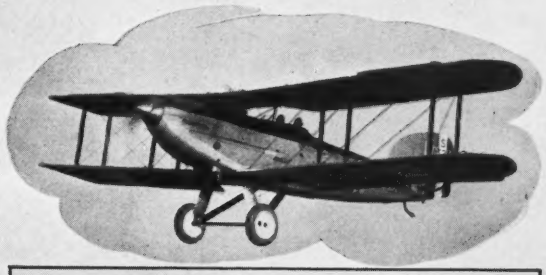
The grant from the Daniel Guggenheim Fund for the Promotion of Aeronautics was utilized in providing new laboratories and increased facilities for the Department of Aeronautical Engineering.

AND then came Lindbergh's flight to Paris.

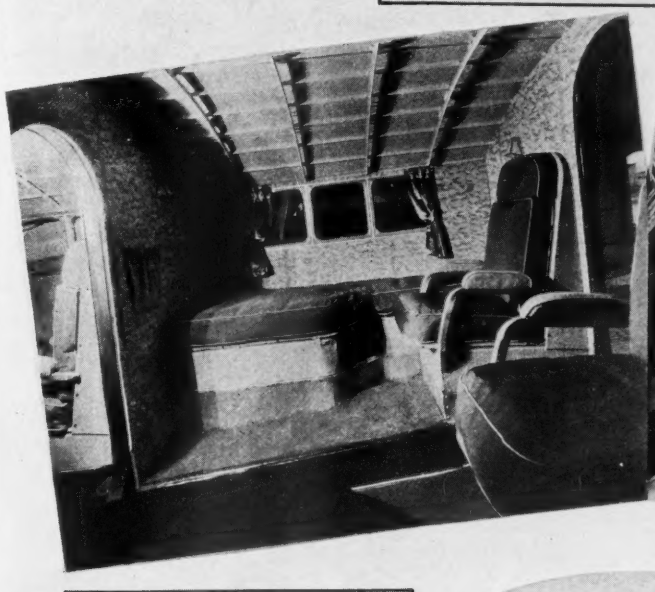
The situation in every branch of aviation changed almost over night. While the general public did not commit itself to the use of airways in place of railways or highways, it became sufficiently air-minded to experiment to the extent of one or two short flights. The airports of the country were crowded every pleasant afternoon by people who visited them to "take a ride." As a consequence, the demand for the smaller, "joy-hopping" types of airplanes increased far beyond the capacity of the industry and the year 1927 closed with most manufacturers having unfilled orders on their books. Such a situation called for further and more radical expansion, so old companies were reorganized and new ones were formed. The public poured its funds into aeronautical enterprises with the result that many projects were started that were economically unsound. New airways were developed and equipment for their operation was purchased, thus creating a demand for the larger transport types that was largely artificial. Many of these lines can now justify their existence neither from a demand for a faster passenger service than that provided by the railways, nor from a demand for more expeditious mail or freight service. But the demand for airplanes having been created, the industry expanded to supply them.

This expansion commenced during 1927 and continued until well along in 1929. As one of its consequences, it created a demand for aeronautical engineers, a demand that was particularly urgent from the standpoint of the industry since it had to have engineers to present design data in a form to meet the approval of the regulatory branches of the Department of Commerce. The government services, universities and the staffs of competing manufacturers were raided in the search for competent engineers and salaries went far beyond the dreams of the most hopeful. Men who were out of college but a year or two, draftsmen who had had little or no technical training became chief engineers of new companies at salaries which, when compared with those received by equally competent men in other branches of engineering, were fabulous and in many cases unwarranted. Echoes of these rapid advances resounded throughout the halls of practically every college or university in the country and, though many of the men who advanced so rapidly have since been convinced that their ambition exceeded their ability, the record of their promotion remains to lure a great many men into aeronautics.

(*Continued on page 168*)



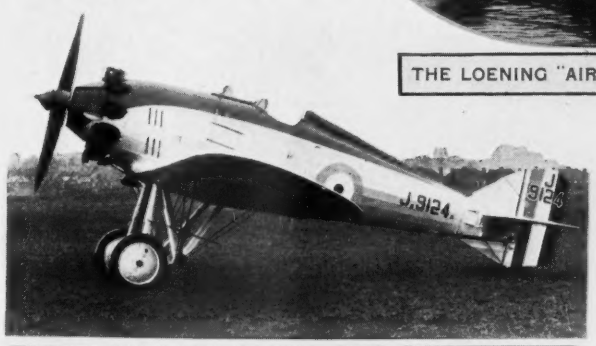
FAIREY IIIF TYPE AIRCRAFT EQUIPPED WITH NAPIER "LION" ENGINE. (GREAT BRITAIN)



ONE OF THE SECTIONS INTO WHICH THE CABIN OF THE CONSOLIDATED "COMMODORE" IS DIVIDED. (U. S. A.)

SLEEPING EQUIPMENT OF THE KEYSTONE 20-PASSENGER "PATRICIAN." (THREE 525 H. P. WRIGHT "CYCLONE" ENGINES) (U. S. A.)

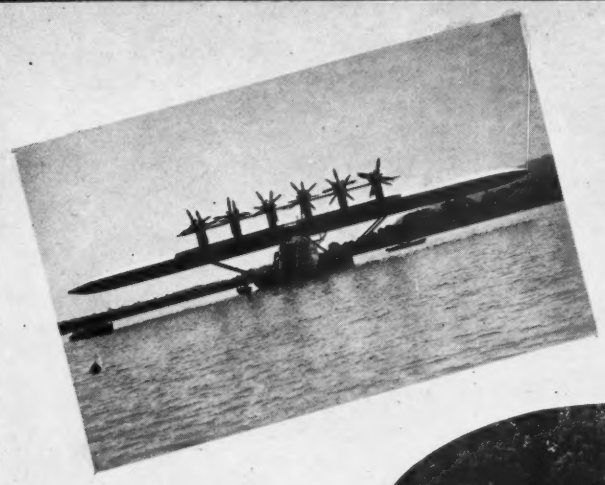
THE LOENING "AIR YACHT." (U. S. A.)



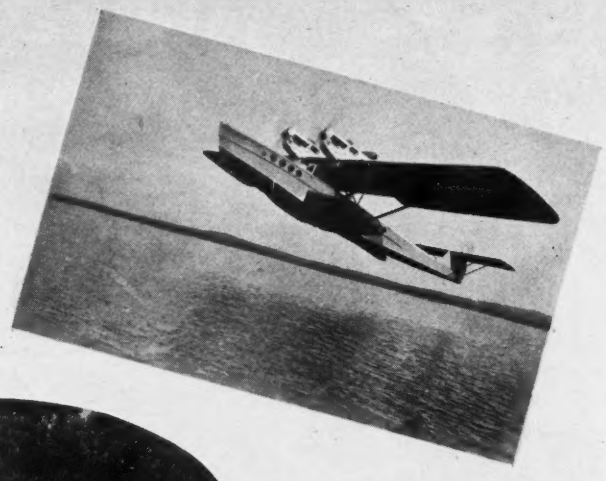
THE WESTLAND SINGLE-SEAT INTERCEPTOR FIGHTER MONOPLANE. (BRISTOL "MERCURY IIA" ENGINE) (GREAT BRITAIN)

THE BLACKBURN "IRIS III" COASTAL PATROL FLYING-BOAT. (THREE 650 H. P. ROLLS-ROYCE "CONDOR" ENGINES) (GREAT BRITAIN)

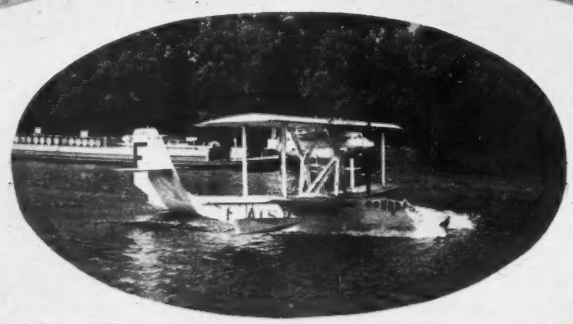
THE CURTISS "CONDOR" COMMERCIAL BIPLANE. (TWO 600 H. P. CURTISS "CONQUEROR" GEARED ENGINES) (U. S. A.)



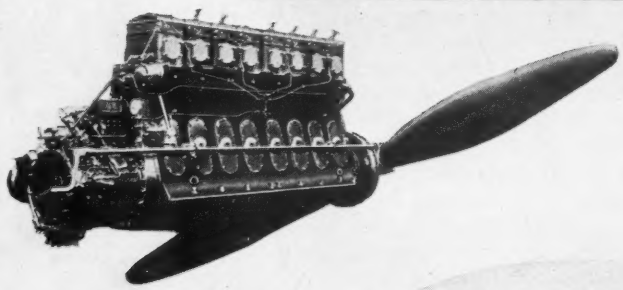
THE DORNIER DO.X FLYING-BOAT. (TWELVE 525 H.P. SIEMENS "JUPITER" ENGINES) (SWITZERLAND)



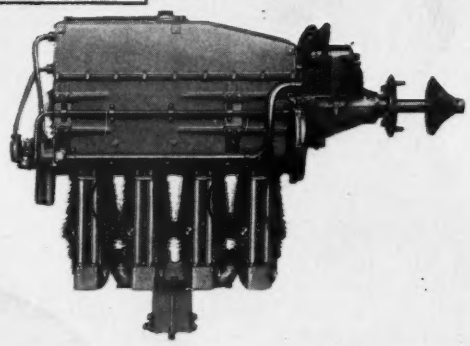
THE DORNIER "SUPER-WAL." (FOUR 500 H.P. "JUPITER VIII" GEARED ENGINES) (GERMANY)



THE C.A.M.S. 53H COMMERCIAL FLYING-BOAT. (TWO 500 H. P. GEARED HISPANO-SUIZA ENGINES) (FRANCE)



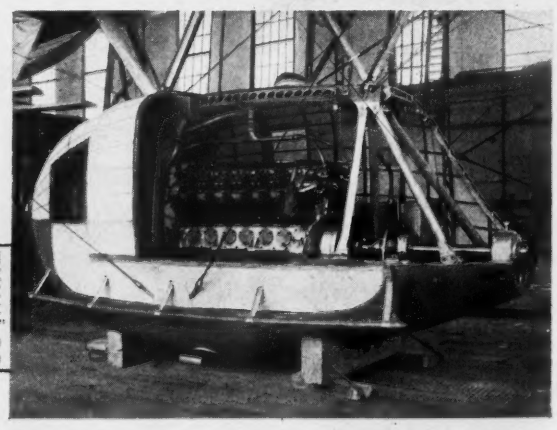
BEARDMORE 8 CYLINDER HIGH SPEED DIESEL ENGINE USED ON BRITISH AIRSHIP R 101. (685 H. P.) (GREAT BRITAIN)



THE ARGUS AS.8 INVERTED IN-LINE ENGINE. (80 H. P.) (GERMANY)

THE BLERIOT 127 MULTI-SEATER FIGHTER MONOPLANE. (TWO 500 H. P. HISPANO-SUIZA ENGINES) (FRANCE)

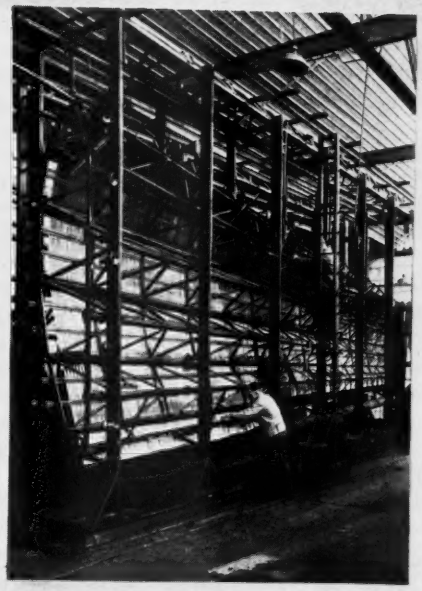
MEALS IN THE PASSENGER CABIN OF THE JUNKERS G 31



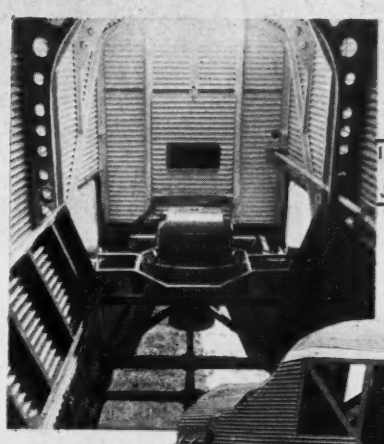
THE MAYBACH AIRSHIP ENGINE OF THE TYPE USED IN THE "GRAF ZEPPELIN" FLIGHTS. (550 H. P.) (GERMANY)

THE JUNKERS G 38

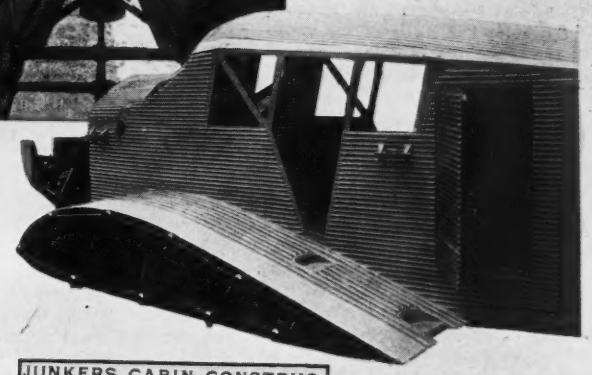
CROP DUSTING WITH THE JUNKERS W 33



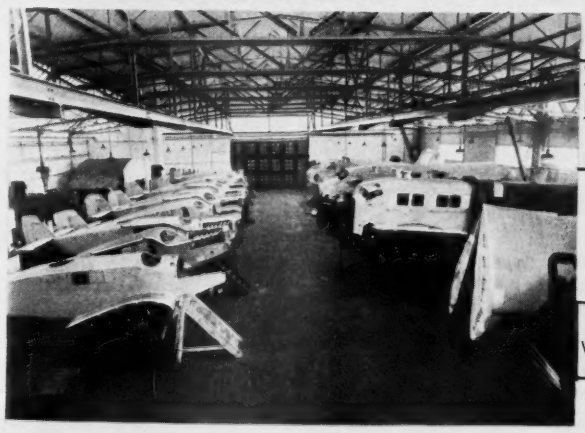
WING OF THE JUNKERS G 31 UNDER CONSTRUCTION



INSTALLATION OF CAMERA IN THE JUNKERS W33/34



JUNKERS CABIN CONSTRUCTION OF THE F 13



VIEW OF ONE OF THE ASSEMBLING SHOPS AT THE JUNKERS AIRCRAFT WORKS

CABIN OF THE JUNKERS G 31 WITH AMBULANCE EQUIPMENT

The School of Chemical Engineering Practice

How advanced students acquire valuable experience in the practice of their future profession

By WILLIAM PATRICK RYAN, '18
Professor of Chemical Engineering
Head of Department of Chemical Engineering
Massachusetts Institute of Technology

WHEN, in 1888, the Massachusetts Institute of Technology offered a definite course of study in Chemical Engineering, it gained the distinction of being the first educational institution to recognize that profession. To what extent this was a pioneer course may be judged from the fact that it was but eight years after the first public recognition of the profession, an attempt to found a Society of Chemical Engineers in London (1880); ten years before the next course was offered, the one at the University of Michigan (1898); and twenty years before the organization of the American Institute of Chemical Engineers (1908).

It is interesting to study the gradually changing object of the course in Chemical Engineering as revealed by the Institute catalogues from 1888 to 1930. In 1888, the announcement of the course read:

> The course is arranged to meet the needs of students who desire a general training in mechanical engineering and at the same time devote a portion of their time to the study of the application of chemistry to the arts, especially to those engineering problems which relate to the use and manufacture of chemical products.

Whereas in 1930, the catalogue reads:

> To prepare students capable of filling the demand for men competent to build and operate manufacturing industries based upon chemical principles is the purpose of this course in Chemical Engineering. The professional work of the course falls naturally into three groups: first, courses which provide a thorough knowledge of the fundamental principles of chemistry. Second, those courses which furnish a sound knowledge of mechanical engineering subjects, both in theory and practice. Third, courses which deal with chemical engineering as a separate entity."

The two statements indicate two very significant changes in the original course; first, the change in the relative importance of chemistry and mechanical engineering in the subjects of instruction, and, second, the fusion of these two into a distinctively individualistic branch of engineering.

ALTHOUGH it is the purpose of this article to deal with but one phase of that development, The School of Chemical Engineering Practice, it is considered desirable to sketch in some of the early background of the course that the reader may understand more clearly the part it plays in the Institute's scheme of Chemical Engineering education.

It was but natural that the chemical engineer early turned his attention to those industrial operations which lie in the borderland between chemistry and engineering; sometimes the work involved more engineering than chemistry and was referred to as chemical engineering; again, it involved more chemistry than engineering and was called applied chemistry. Thus within the course two phases of the profession were early recognized, and are today so recognized, the engineering and the applied chemistry. The needs of the latter were fostered by the establishment, in 1908, of the Research Laboratory of Applied Chemistry, the chief purpose of which has been the training of young men in applied chemical research. It was not until 1915, however, that the work of the engineering phase received somewhat similar support.

In that year, Dr. A. D. Little, as Chairman of the Visiting Committee of the Department of Chemistry and Chemical Engineering outlined in his report to the President and the Corporation of the Institute a plan for the systematic study of the engineering phase which has had a world-wide influence on chemical engineering education. To quote from that report:

> Any chemical process, on whatever scale conducted, may be resolved into a coördinate series of what may be termed "Unit Operations," as pulverizing, drying, roasting, crystallizing, filtering, evaporation, electrolyzing, and so on. The number of these basic unit operations is not large and relatively few of them are involved in any particular process. The complexity of chemical engineering results from the variety of conditions as to temperature pressure, etc., under which the unit operations must be carried out in different processes, and from the limitations as to materials of construction and design of apparatus imposed by the physical and chemical character of the reacting substances.

Although this was the first official pronouncement of the unit operation method of study, reference to the Institute catalogue indicates that as early as 1900 the importance of some of these unit operations was recognized, as may be judged from the following:

> A course of instruction in the fourth year is devoted to evaporation, distillation, refrigeration, and similar topics.

Not only did Dr. Little's report sketch a definite system of training in basic chemical engineering principles but it included a comprehensive plan of putting that scheme into execution by a coöperative method of education differing from the many variations of the Cincinnati plan then in practice.

BRIEFLY stated the distinctive features of the School of Chemical Engineering Practice were:

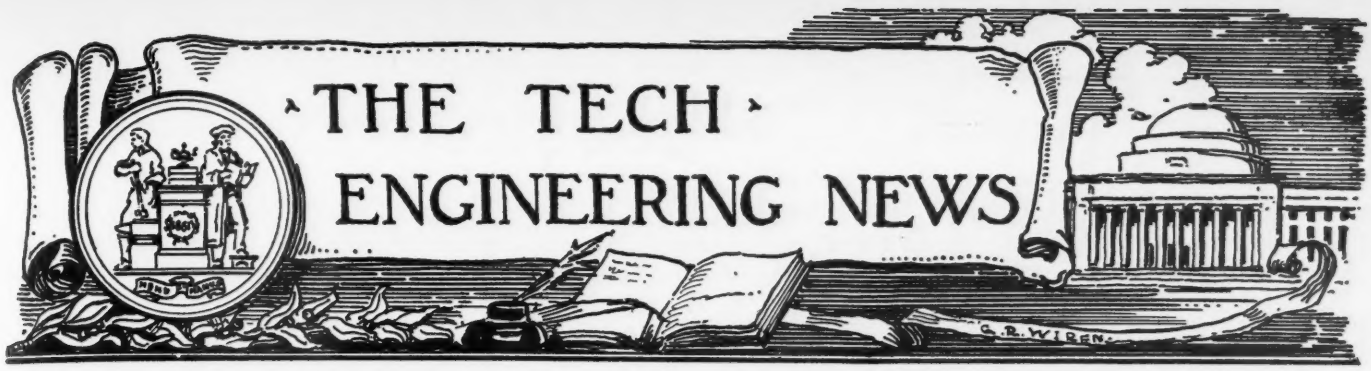
1. The students were to complete their basic training in science and engineering before entering upon the industrial application.
2. The plant work was to be intensively educational, and, therefore, the students were to receive no pay from the coöperating companies.
3. The plant work was to be carried on under the supervision of members of the department staff, resident at the plant and devoting their entire attention to it.
4. After completing the industrial work, the students were to return to the Institute for such graduate instruction in science and engineering as appeared desirable, the subjects being, in the main, elective.

Although this plan differed then, as it does now, from any other coöperative plan in engineering education, its similarity with the system of medical education is worthy of note.

Dr. McLaurin, then president of the Institute, authorized Dr. Walker, then in charge of the Course in Chemical Engineering, to begin active work toward putting the plan into action. Mr. Eastman, then known as the "Mysterious Mr. Smith," because of his anonymous gifts to the Institute, generously gave the necessary funds for a five-year trial of the plan.

The plan was put into action with the Class of 1917, but, because of the entrance of the United States into the World War the work had to be abandoned after what may be termed an experimental period. Profiting by this experience changes were made in some of the details when the plan was resumed in 1920.

Since then the School of Chemical Engineering Practice for those who have received their S.B. in Chemical Engineering at the Institute consists of eleven months of graduate work; six months spent in industrial plants and five months in receiving instruction in science and engineering at the Institute. Because the industrial work is the distinctive feature, there is a tendency to refer to it as the "Practice School" but it should be emphasized that the formal instruction in advanced subjects at the Institute is an integral part of the scheme.



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Editorials

STOCK TAKING IN AVIATION

PROF. EDWARD P. WARNER, in his article on "The American Aircraft Industry," has called attention to some vital factors concerning aviation. He has pointed out the necessity for the industry to take stock of itself, to find out where it actually stands, and what the prospects for the future are, these prospects not to be estimated by the enthusiasts for aviation blindly carried away by their own enthusiasm, but by a sane and careful analysis of all the factors which can be dealt with which vitally affect the condition of the industry. Too long the industry has listened to the voice of the booster who intrigued by the romance of aviation has made careless forecasts and unsupported statements without looking closely into the actual facts of the case. We have all heard such statements as these in years past: within five years there will be as many airplanes as automobiles; the aeronautical industry is following the path of the automotive industry and within five years will exceed it in size; 20,000 airplanes will be sold during the coming year. Yet as the time for these prophecies to be fulfilled has arrived, they have not been borne out. The delusion which such a state of affairs implies, if allowed to continue, can only result in eventual trouble for the industry as a whole. To be successful, the aeronautical industry must be built upon a sound foundation in the same manner as any other industry. Any other sort of foundation can only bring the eventual slump and disaster.

Another point which might well be considered at this time is the large number of airplane manufacturing companies in proportion to the total number of airplanes produced. Today there are more airplane manufacturing companies in the United States than automobile companies, while of course there is no comparison in the amount of business done. This condition is economically unsound and we can look for a high mortality rate in airplane companies until it is corrected.

This rate has been somewhat reduced through mergers which have helped the financial conditions of the smaller organization. However, this condition is not as good as it might be, for the duplication of plants and equipment in widely scattered parts of the country, and the increased overhead of a large number of units, means that manufacturing costs cannot be as low as would be possible with a single large plant in one location.

The airplane and the automobile are of practically the same age, and today the automobile industry far outstrips the airplane. The airplane has pioneered travel in a new medium, and has had additional problems to overcome which did not face the older forms of surface transportation. Possibly some time in the future conditions may be reversed, but before that can come about, many problems will have to be solved and it is probable that aeronautical growth will be slower than people have been led to expect. For that growth to be steady and to be sure, the industry must be upon a sound basis, and for that to be attained it must face the facts.

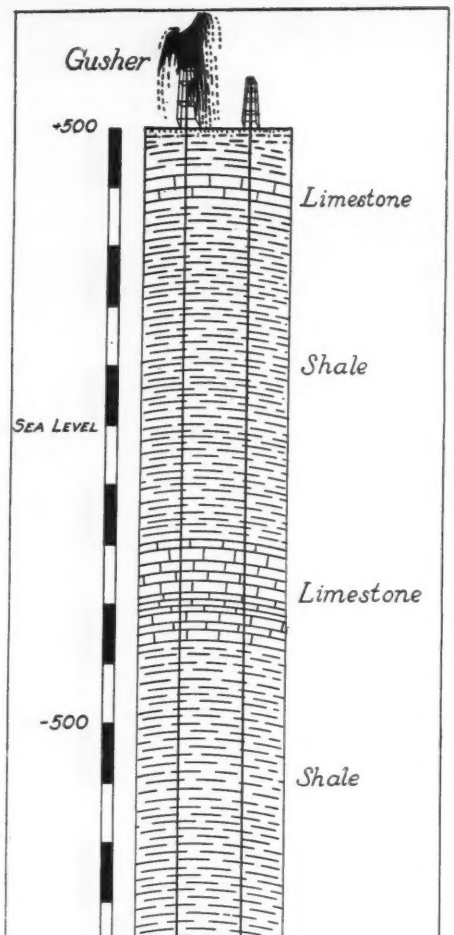
ELECTIONS

We take pleasure at this time in announcing the following elections: J. R. McCaa '32, Assistant Editor; E. R. Atkinson '33, Assistant Managing Editor; D. G. Fink '33, Assistant Editor; G. P. Bentley '33, News Editor; W. B. Huston '33, Features Editor; H. G. Protze '33, Art Editor; C. E. Buchanan '33, Assistant Treasurer; E. H. Lloyd '33, Assistant Advertising Manager; K. H. Clark '33, Assistant Advertising Manager; S. L. Brown '33, Assistant Advertising Manager; G. Cary '33, Assistant Circulation Manager; C. V. Case, Jr. '33, Assistant Publicity Manager.

Departmental Notes

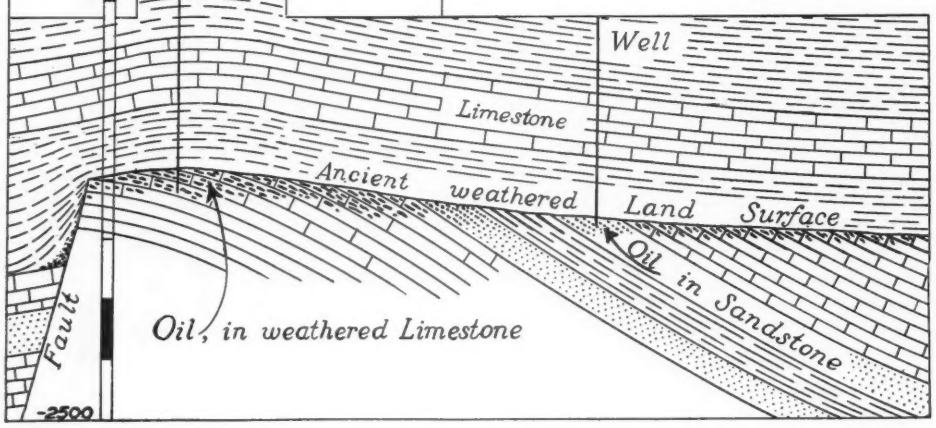
DEPARTMENT OF GEOLOGY

THE work of the Department of Geology is generally not well understood by undergraduates. The average man would be likely to think of it (and correctly) as involving the history of the earth, the successive sedimentary beds, the volcanoes, the glaciation, the rocks, the structure of mountain ranges, in brief, as a science interesting and inspiring, but he would scarcely realize its practical import and its many contacts with many of the other departments of the Institute. Really, the Department should be named "Geology and Geological Engineering," or "Geology and Applied Geology." All of the branches of the science are taught including mineralogy, petrology, dynamic geology, paleontology and stratigraphy to serve as a firm foundation for those who are making geology their life work as teachers, as members of surveying organizations, or as geologists to industrial corporations. Elementary general science courses are offered for those of other departments who desire a general or cultural knowledge of the science and its application to the mineral industry. A long series of courses in Applied Geology are given to miners, metallurgists, civil engineers, architects, construction engineers and others. Many of such courses in applied geology are of an advanced character, but these are mainly for the professional geologists. Every engineer, none excepted, should know at least something about mineralogy, that is, about the unit chemical compounds of which the earth is built. He should also know something about rocks and soils for he is certain to run up against that subject in any part of his professional career. To mining students a new course is given relating to the microscopic identification of ore minerals in the comminuted products of ore concentration so that the progress and improvement of such processes may be directed.



PROFILE OF OIL WELL IN OKLAHOMA

Drawn to scale this profile shows the accumulation of oil in three diverse types of structure.



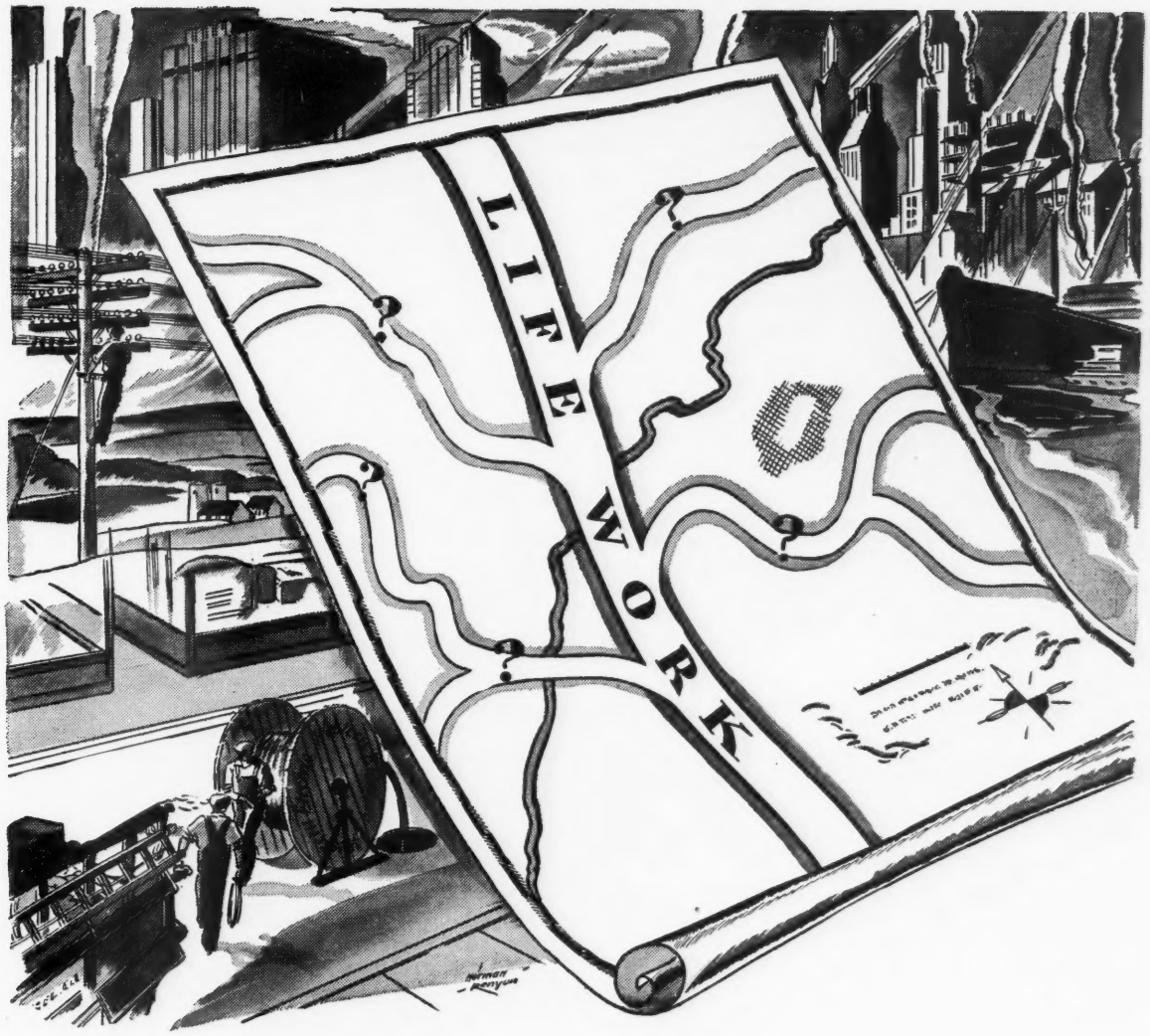
PHYSICAL crystallography, that is, the study of crystal forms, has recently been added to the curriculum and a new two-circle goniometer, a very expensive instrument, has recently been acquired. Crystal atomic structure, a modern development, is a part of some of the courses and in this field coöperation with the Department of Physics is established. Everyone who has attacked the subject of optical crystallography will remember its difficulties; one member of the Department is at present working on a textbook dealing with this subject.

In paleontology mention should be made of the acquisition of two hundred specimens showing the evolution of ammonites — a group of shells related to the Nautilus. Development of new characters and the loss of old ones, acceleration and retardation in evolution, all is wonderfully clearly shown. Probably most men would regard such studies as extremely interesting from the standpoint of abstract science but of little economic use. Here again, however, the scientific research of yesterday is translated into practical results of today for the study of the occurrence and evolution of microscopic faunas forms invaluable aids to the location of certain beds and micropaleontology is now a handmaiden to petroleum geology, and paleontologists are in the employ of oil corporations all over the world. Many students in the Geological Department are pursuing such investigations.

Structural geology investigates the relation of rock masses either by original deposition, or as influenced by the application of external and later forces. All geologists study and teach structural geology. Some of it may seem abstract and abstruse, but here again practical applications of great importance follow. For oil geologists structural geology is the principal instrument to locate petroleum deposits. For students of ore deposits the relation of ore to structure often leads to great discoveries so that much emphasis is laid in various courses on this relationship.

FOR the civil engineer the bearing of geologic structure and geologic agencies on practical engineering projects is most important and neglect of such investigation has led to some terrible failures in the construction of dams, water supply and tunnels. In

(*Continued on page 168*)



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Recent Books

This department conducted in co-operation with the faculty

Modern Aviation Engines. *By* MAJOR VICTOR W. PAGÉ, *Air Corps, U. S. R. Norman W. Henley Publishing Company, New York City. In Two Volumes. 1908+XL pages. 918 illustrations. 50 tables. Price $9.00 net. Volumes sold separately at $5.00 each.*

THE author of these books, Major Victor W. Pagé, has had a wide experience in the design and manufacture of aeroplane engines since the beginning of the American aviation industry and is now actively engaged as a consulting engineer. Besides his own experience he has had the help and coöperation of the leading airplane and engine manufacturers, as well as the United States Army and Navy Air Services in the compilation of these volumes.

The aim seems to have been to present as much complete information as possible concerning the different types and kinds of aviation engines in use today, without influencing the reader for or against any particular type, but allowing him to draw his own conclusions in regard to their respective merits. The two volumes contain a total of forty-six chapters describing the various leading American, English, French, German and Italian aeronautical engines. Volume One, containing chapters one to twenty-seven inclusive, takes up thermodynamics, efficiency of engines, methods of testing; engine parts and their functions; aviation fuels; carburetion and fuel supply systems, superchargers; ignition systems; engine lubricants and lubricating systems; air and water cooling methods, etc. Volume Two of the same size as the first volume covers the remaining chapters and contains much matter relating to specific engines and methods used in their installation, service, repair, testing and flight operation. A good deal of this material has come from manufacturers' handbooks. Besides the material dealing with engines there are other chapters covering instruments and their use; air, electric and inertia starters; propellers; reduction gears and their applications. An exposition of tools and special fixtures for engine repairing is included and tables of clearances for the various engine parts are given. The books are replete with photographs, charts and drawings explaining structural details and operating principles.

The entire work is written in non-technical language, with but a very slight use of mathematics and formulae. In explaining the operating principles of engines and their parts the author has succeeded in using simple illustrations which are easily understood by the layman. The practical information included makes it a valuable book for the shop man and mechanic. For the engineer its chief value lies in the large number of different types of engines with the descriptions and illustrations of their construction and operation here collected together, making the whole a good reference work.

A. B. B.

The Wright Brothers: Fathers of Flight. *By* JOHN R. MCMAHON. *Little, Brown & Company, Boston. 308 pages+VII. 24 illustrations. Price $2.50.*

THE editor dropped in the office one morning with the intention of putting in a good two hours' work on some important matters relating to the publication. However, the editor's plans went astray, as they often do. For there on his desk lay a new book, just sent in to be reviewed. He opened it up to see what it was like, and thereupon became so engrossed in it that a whole morning slipped by — work, classes, and everything. This book contained the story of the Wright brothers.

"The Wright Brothers" is a book that will satisfy a number of different types of readers. For those interested in the history of the airplane, a complete account of the connection of the Wrights with it is given. Mr. McMahon has access to the diaries of the brothers, as well as to all their correspondence. He explodes some popular fallacious notions concerning the origin of the airplane and gives practically the whole credit of its invention to the brothers.

For the person interested in the environmental and psychological aspects of human life, the heritage of mechanical ability and adeptness given by the Wrights' ancestors is demonstrated, and the development of ingenuity in them is faithfully traced — how, as boys, lack of money forced them to exercise to the utmost their skill in making their own toys and how this habit later aided their resourcefulness in making an airship practically from odds and ends.

Finally, those persons mainly interested in people as human beings, will find in this book a very human story indeed. The author has been careful to include all the material possible to make the famous inventors live. This he is qualified to do, as he is acquainted with those members of the family still alive.

No one will regret having read this book. Mr. McMahon is a writer of considerable experience, and his whimsical fashion of recounting the trials and triumphs of the Wright brothers is a delightful relief to some of the heavy biography which students have to read.

J. H. D., JR.

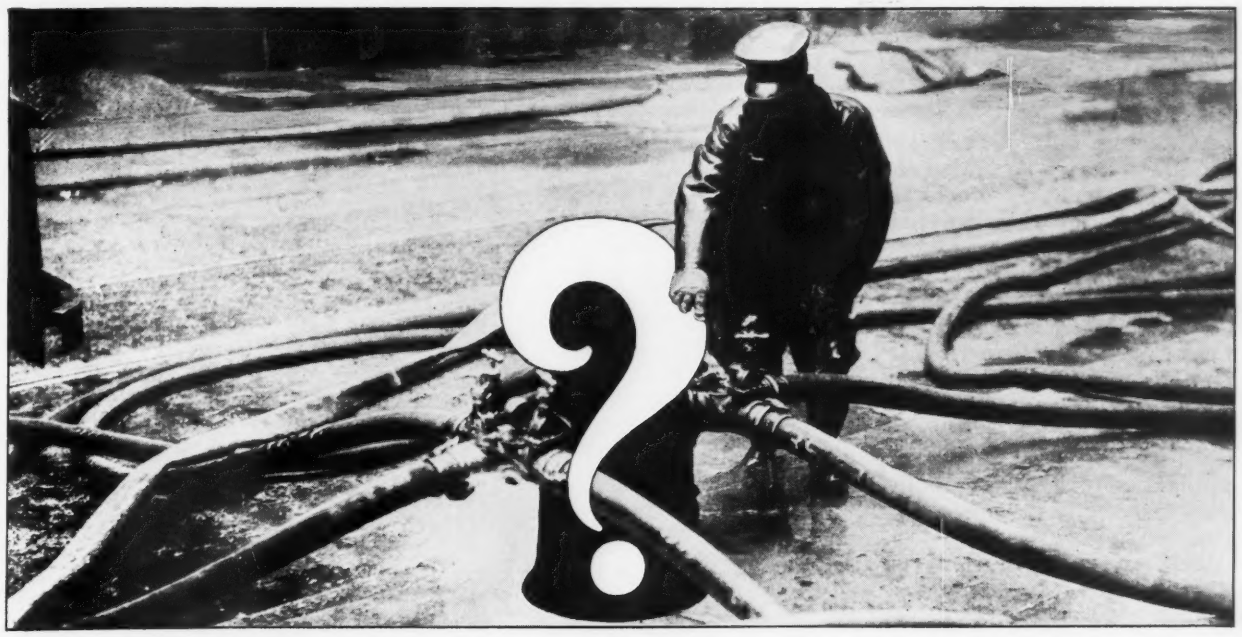
The Navigation of Aircraft. *By* LIEUT. LOGAN C. RAMSEY, U. S. N.; *formerly Officer in Charge, Section of Aerial Navigation, Hydrographic Office, Navy Department. 1929. The Ronald Press Company, New York. 237 pages. 50 illustrations. Price $4.50.*

THERE is a definite growing need for the flyer to know something of aerial navigation, with the increase in the number of aircraft being operated and the longer flights which are being made. Not only is it important for its usefulness in aiding the flyer to arrive safely at his terminal point, but it has a very definite economic value in cutting the cost of operation of aircraft, for it is obvious that the flyer able to proceed directly on his route, taking the shortest distance, will spend fewer flying hours in the air with consequently less flying expense.

Lieutenant Ramsey's book was written with the purpose of making available to the flyer some knowledge of navigation as applied to aircraft. In taking up the subject of aerial navigation he divides it into three classes: piloting, dead reckoning, and aerial astronomy. Practically all of the old-time flyers depended entirely on piloting, that is, finding their way from place to place by the visible landmarks they were able to pick out upon the surface of the earth. Lieutenant Ramsay points out that with the moderate distances which were flown, the consequences of such crude flying were not serious, but that such a pilot will find himself out of date with the increasing distances of today.

With flights over 200 miles in length, some form of navigation should be used, and he believes that the most suitable form for flights between 200 and 800 miles is dead reckoning. For those distances it is closely accurate, and the expense of the equipment needed for the more complicated astronomical navigation is not warranted. In explaining dead reckoning he gives quite a number of problems which are worked out entirely with graphical methods as being the quickest and easiest type of solution for practical

(*Continued on page 164*)



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A BETTER PRODUCT—GIVING BETTER SERVICE—AT NO PRICE INCREASE

The American Aircraft Industry

(*Continued from page 127*)

Manufacturing and Selling

There was little commercial work in aircraft manufacture until 1924. Prior to that time the industry depended almost entirely upon military orders to take care of its output. During that year, however, a group of young men, most of whom had seen service during the war, decided to manufacture airplanes to be sold commercially. By 1929, after two years of constantly increasing production, the demand for commercial ships was greater than the supply available. Production was not able to keep up with it.

The combination of seemingly limitless demand and the large amount of money available to aviation companies through stock issues caused many of them to build expensive factories. There were optimists who thought that the demand for aircraft would outrun that which the automobile industry had witnessed for automobiles. Little thought was given to find out who the buyers were to be, and for what purposes the airplanes were to be bought.

In the fall of 1929 the demand slackened, and by the end of the year a good many companies found that they had a considerable number of airplanes on their hands which they were unable to sell. They also had more time, and improved it by investigating to some extent the demand for airplanes, but the various manufacturers did not agree upon the results of the investigation. Some thought that the public would buy airplanes if the prices were cut, and that with the demand thus made and increased production, the airplane manufacturing companies would make good profits. Others thought that there was nothing wrong with present airplane prices, that all that was necessary was to reach the right people and convince them with a good sales campaign. Still others believed that easier flying and safer airplanes were necessary before the public would begin to buy extensively.

TODAY the airplane manufacturers may be divided into three groups:

I. Those believing that an intelligent classification of the present market for airplanes is necessary. Nearly all the manufacturers agree as to this.

II. Those believing that price cutting is essential to sales.

III. Those who believe that some form of miracle is necessary to increase sales.

The third group is dishearteningly large. Some of its members believe that the public will not buy airplanes in any number until they are able to land at some such speed as twelve miles per hour, or until the maximum speed is six times the minimum, etc. Others believe that aviation will succeed when planes are built large enough, yet large planes have as a rule proved more or less disappointing commercially. Every little while the prediction has been made that as soon as a certain large plane has been built, then in process of construction, we would have trans-Atlantic service and real aviation would be here. But each time the plane has been completed and tested and has not come up to the expectations of the visionaries, another large plane in course of construction is chosen as the one to open a new heaven and earth. Some operators believe that as soon as they can get passenger airplanes able to carry fifty passengers that they will be able to operate at a good profit.

Having received a B.S. from M. I. T. in 1917, Mr. Warner had been connected with this Institution for over ten years when he left last year. Upon his graduation, he became an instructor in Aeronautical Engineering. Following the war, he was connected with the National Advisory Committee for Aeronautics. In 1920 he became Associate Professor of Aeronautical Engineering, and in 1924, Professor. He was appointed in 1926 Assistant Secretary of the Navy for Aeronautics. Mr. Warner is at present Editor of "Aviation."

The possible markets for airplanes can be divided into four main groups:

I. Transport companies.

II. Operators of flying schools, taxi services, short rides, etc.

III. Business houses.

IV. Private owners.

All the classes have distinct purposes for which the airplanes they want are to be used.

Considering group one, the transport companies. Last year the American air transport lines flew a total of twenty million miles. A transport airplane properly cared for has a relatively long life. A fair average for one is four years, flying about 3,500 hours a year, or about 400,000 miles at a rate of 110 miles per hour. It can thus be seen that with the present mileage being flown yearly that only about fifty new transport planes would be needed per year for replacements, and as most of the lines are now almost newly well equipped there is likely to be little replacement business for some years to come. But when it does come, the building of fifty planes a year is rather small business. Therefore, unless a large number of new lines are started, or the export of transport planes can be increased, there is little likelihood of a boom in the air transport manufacturing business. Everything depends on further expansion of operations or on introducing transport planes in "joy ride" service.

The second group, the operators of aerial services and schools, were largely responsible for the unit production of 1928 and 1929. They are also fairly well supplied at the present time, so that the market here has been sharply cut down.

The third group, business houses, often bought airplanes to fly around the country for the advertising thus given them. As more business houses bought airplanes, the advertising value naturally fell, in the inverse ratio of the number of houses owning planes. Some of these after flying their airplanes for a year and checking upon the costs, have decided to sell them, which of course does not help the market for new planes. Others, fortunately, have found that the ownership has been of real aid and economy, and are keeping the planes they have or even buying additional ones.

Class four, that of the private owner, is relatively an unexploited field. There are today not more than five or six hundred privately owned airplanes in this country, and if a strict interpretation is put upon the words "private ownership," probably not more than half of this number could be so listed. This market is in the cradle stage. There is, however, a limit to the number of people who fly for pleasure or for sight-seeing, or who will keep on flying for the sake of flying after the novelty has worn off.

From the above, it can be seen that three of the four groups have received a check at the same time, and although there may be business in prospect from them eventually, it will not help the present situation.

To get increased production it is necessary for the manufacturers to

I. Make a careful analysis of the market for airplanes.

II. Be economical in the production of airplanes.

III. Increase the safety, ease and comfort of flying.

Manufacturers cannot well sell below cost or they would soon be out of the airplane industry, but they can reduce costs through economical methods of manufacture.

The early manufacturers were almost entirely war-time pilots, and hence looked at an airplane from that point of view. They built a plane that

(*Continued on page 150*)

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Aircraft Industry

(*Continued from page 148*)

could be stunted, and flown as the war airplanes were. However, a stunt demonstration is not likely to increase the confidence of a business man who wants to take his wife and two small children out for an airplane trip to a nearby city. It is more likely to make him feel that aviation is not for him. More consideration must be given to the wishes of those whom the industry hopes to make the owners of private airplanes. Safety and ease of flying are things which the industry cannot take too keenly to heart.

In conclusion, it might be said that the people must be reached by every possible means, but there are certain things which must not be done. The public cannot be sold by high pressure sales talks. Such a course only develops a greater number of airplane salesmen, each with an airplane and no one to sell to. It cannot be sold permanently by the romance of aviation. There has been too much self-deception as to the actual condition of aviation. We must look for and find the facts, and tell both ourselves and the public the truth. Airplanes, like everything else, will in the last analysis have to stand or fall upon their merits or demerits, and not upon statistics made to order to secure a desired effect.

STANDARD
INSTRUMENTS
OF PRECISION

C. L. Berger & Sons, Inc.
Established 1871
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The Seadrome

(*Continued from page 129*)

sion, all of which are over 40 years old, 76 are 50 years old, 26 are 60 years old, 4 are 70 years old and 2 built in 1846 have reached the ripe old age of 84 years. The life history of anchored lightships has been studied and gives additional support to the opinion that the seadrome structure, constructed as planned, will not experience corrosion sufficient to affect its strength or performance during the first twenty years of its life. As the amortization period calculated upon in the financial set-up is ten years that figure seems quite conservative.

SEADROME dimensions are those found necessary for stability and safety at sea and exceed those required for airway operation, according to landing and takeoff experiments carried out at Roosevelt Field from a seadrome area in which a twin-motored Sikorsky amphibian airplane was used. On the average but 60 per cent of the central runway was required for landing and takeoff of planes, without the use of brakes. In view of the trend to larger planes provision is made in the structural design to permit lengthening the landing deck at sea from two to four hundred feet, to an ultimate length of 1,500 feet or more should this prove desirable after some service experience. A considerable increase in length would not materially increase the stresses in the seadrome structure because the maximum wave length encountered at sea is the stress controlling factor after the length of the floating structure exceeds 1,000 feet. From a structural and stress point of view a seadrome could be 1,800 feet long, or more if necessary.

Edward R. Armstrong, who originated and is developing the seadrome project for ocean airways, was a pioneer in aviation, is a member of the "Early Birds," having built and flown an airplane in 1911, at which time he was a consulting engineer in the field of automotive development, speed boats, automobiles and airplanes. Following a varied experience in civil, mechanical, electrical and chemical engineering he became associated with the duPont Company, in 1914, and has remained with this Company ever since. In 1919 Mr. Armstrong was placed in charge of the Mechanical Experimental Division of the Engineering Department, which position he has held continuously until taking a leave of absence in 1927 to devote all his time to the seadrome project. Mr. Armstrong is a member of the A.S.C.E., A.S.M.E. and A.I.E.E.

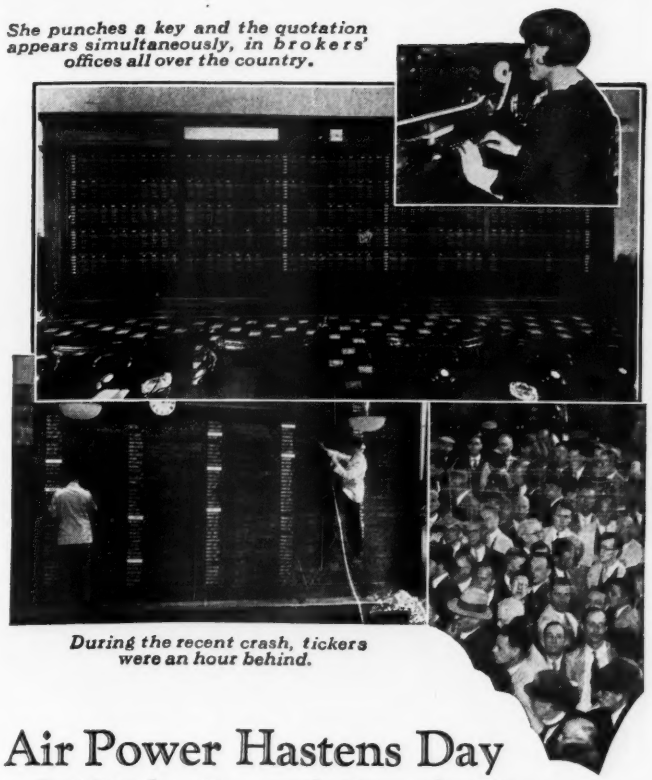
While the design laid down includes hangars and personnel space on both sides of the deck, it is feasible and less costly to limit hangar space to one side, at least until the test period has been successfully passed, and provide personnel quarters in the deck system where there is ample room, so that a much greater width of deck would be available for landing the larger planes which may be developed and put in operation in the near future.

Hotel facilities are very complete and include 40 bedrooms for guests as well as ample accommodations during the day for 350 or more in the various lounges and public rooms planned. Quarters for the personnel will in part be located in between the main deck, the area being sufficient to provide all space required. Lifeboats to seat 240 persons are part of the safety equipment, including a 54-foot sea sled capable of from 30 to 40 knots speed, to be used for patrol and rescue service from the seadrome.

Flood lighting of the landing deck will make landing and takeoff of planes at night as safe and reliable as in the day. Searchlights visible for from 50 to 100 miles from the seadrome is another navigational aid provided, although the radio beacon system to be installed is so simple and reliable that no other directional navigational aid seems necessary.

The anchorage gear towing connection is attached to the two forward buoyancy tanks in line with the lower chord of the main truss system making up the seadrome. The method of attachment distributes the anchorage stress throughout the structure. The design is such that the cable connecting with the anchorage buoy can be led through it to the tension engine, located in the power area, by the operation of which, slack, in the connecting cable, can be automatically taken up and so prevent its fouling the submerged portion of the seadrome.

Fin areas are provided at the stern so as to bring the centre of air pressure aft of the centre of water pressure in order that the seadrome will trail into the wind at any wind velocity in excess of 15 miles per hour, a condition of operation necessary for safe landing and takeoff of planes. To prevent yawing after coming up into the wind air rudders are provided, operated electrically automatically by a damped wind vane. These rudders hold the seadrome into the wind irrespective of the direction or force of the ocean current at those times when the wind is of sufficient force to affect the landing and takeoff of planes.



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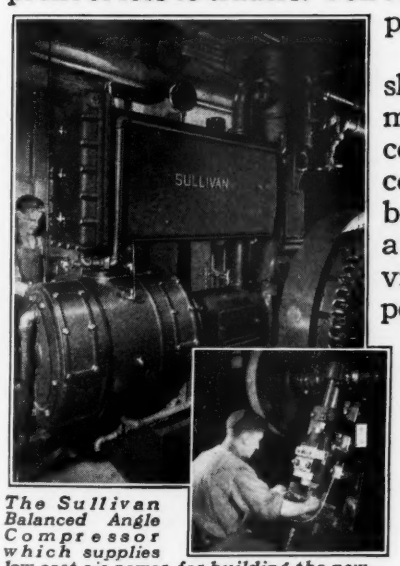

The Sullivan Balanced Angle Compressor which supplies low cost air power for building the new automatic quotation boards.

Send for Compressor Booklet 83-W, and also the booklet "Engineering Sales Opportunities with the Sullivan Machinery Company"

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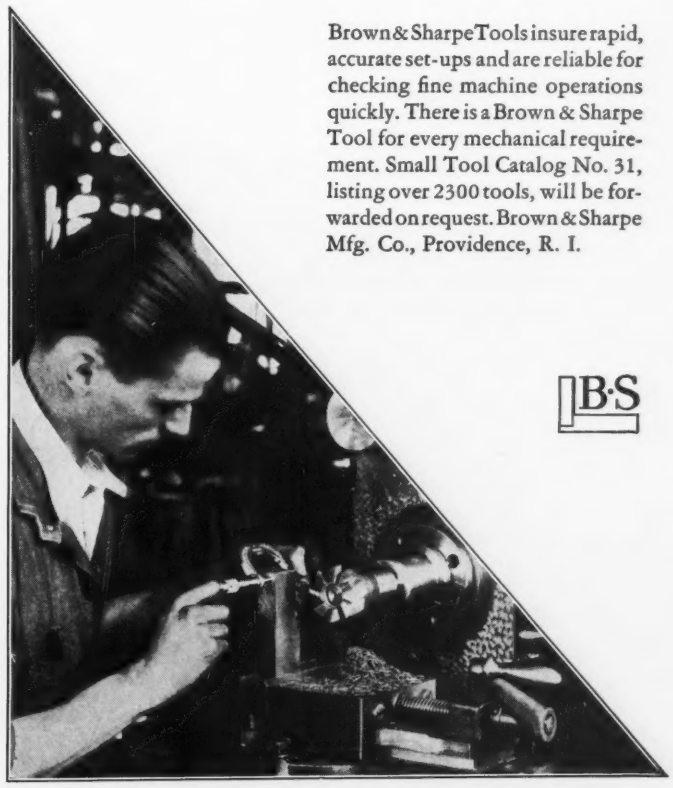

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Lighter-Than-Air Craft

(*Continued from page 130*)

for the construction of two large rigid airships, has had the vision to select a size and type that are exceedingly suitable for a long-distance commercial vehicle. The new ships are to be helium inflated and have a gas capacity of 6,500,000 cubic feet. This size of helium ship is comparable with hydrogen-inflated ships of a little less than 5,000,000 cubic feet capacity. This difference in capacity is explained by the lower lifting power of helium and the necessity of inflating the bags only so much that no gas will be lost as a result of subsequent expansions in maneuvering.

A PROMINENT feature of the ship is the location of the power plants and the consequent adoption of a new and improved drive system. The eight directly reversible engines are installed in separate engine rooms inside the hull and are connected to rigid driveshafts which extend outside of the hull to the propellers. The use of bevel gears makes it possible to use the propellers, not only for forward motion and reversing maneuvers, but also for vertical thrust by tilting their axes 90 deg. This feature will be of great importance in starting and landing maneuvers. It will also enable the carrying of more payload and avoid the loss of lifting gas when the ship has to be landed against surplus lift.

Accommodations provided for travelers in the proposed ship are of considerable importance and interest. The use of hydrogen as a lifting gas has demanded, for safety against fire hazard, that the passenger accommodations in airships built up to the present time be placed in a car outside of the main structure.

American-built commercial air-liners possess a tremendous advantage in that this country has a monopoly on helium. It is the privilege of Goodyear to build ships using this non-inflammable gas and thus to be able to incorporate new features of safety and comfort into the airship art. Passenger compartments are retracted into the hull, with the result that passenger accommodations may be extended almost at will, while aerodynamic efficiency is considerably increased. Promenade decks, libraries, lounges and smoking rooms are no longer dreams but are actualities.

Erection of the world's largest airship factory and dock upon the great municipal flying field at Akron, Ohio, has been completed by the Goodyear-Zeppelin Corp. The dock is 1,200 feet long, 325 feet wide, and about 200 feet high. It is well rounded in form and equipped with doors of a special spherical calotte design. The avoidance of sharp corners eliminates local regions having extreme air-pressure variations, while the airflow over the whole structure is unusually smooth.

THE utility of small non-rigid airships is perhaps open to question. It is not expected that they will compete with airplanes in the carrying of mail and on short flights, but they possess a great advantage in that they have proved conclusively their ability to land in the smallest and poorest of fields and even on the flat roofs of downtown office buildings. Commercially they are desirable as a means of advertising and of creating goodwill. The larger semi-rigids and the smaller rigid ships are very suitable for aerial photography, surveying and map making. In a military sense the small non-rigid ships are extremely valuable for "spotting" and anti-submarine work.

(*Continued on page 154*)

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Personal interview will be arranged.

DAVID ANDREW, Director of Sales

THE ARCO COMPANY

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Lighter-Than-Air Craft

(*Continued from page 152*)

For observation purposes the airship has unique advantages, because of its ability to remain in the air for long periods or even to float motionless with engines stopped.

A discussion of the lighter-than-air ship would not be complete without a few words concerning the relation existing between it and the airplane. While realizing the advantages of the airplane as a commercial vehicle for carrying comparatively light loads over medium distances at high speeds, the designers of rigid airships have turned their efforts to the erection of large, safe, and reliable ships that will be capable of bettering present methods of transportation over large stretches of land and ocean. Successful completion of the present projects will give added impetus to the present growing appreciation of the airplane. Of what use will be the saving of several days in an ocean voyage by airship if hurrying passengers end their flight only to find nothing but primitive overland travel available for the rest of their journey? The two branches of air travel must advance hand in hand, working not as units but as a group in an attempt to speed up transportation to any and all parts of the world.

Commercial Airline Operation

(*Continued from page 131*)

that no such feeling comes during the progress of an airplane flight. It is unfortunate, too, that until very recently the public's conception of the airplane has been based almost entirely on the dramatic and spectacular performances of some few daring aviators.

THE fact is, there has been too much romance attached to the airplane. The great problem of the air transport operators has been to convince the general public that the airplane is just another carrier, a machine capable of transporting goods and passengers through the air reliably and at great speed.

Considering the problems before the industry, mechanical and human, the progress made by aviation may be said to be remarkable. The first air passenger line to be established in the United States, operating daily between two designated points, was inaugurated in May, 1926, approximately four years ago. The route was between Los Angeles, Calif., and Salt Lake City, Utah. Passenger carrying, however, was secondary to the transport of air mail, but despite the unsatisfactory equipment — open cockpit planes built for military purposes were used — it may be said that transport of passengers by airplane in America dates from that time.

During the past two years it has sprung forward with marked rapidity and the airplane is now beginning to be accepted as a practical utility. To illustrate this point it will be interesting to study air transport statistics for the past four years and note especially the growth made the past two years.

THE Department of Commerce reports that in the year 1926 airplanes operated by transport companies flew 4,318,097 miles; in 1927 the total was 5,870,489 miles; in 1928, 10,673,450 miles and in 1929 the total is estimated at 22,000,000 miles. It will be noted that between 1926 and 1927 there was only moderate growth, but in the following year the mileage doubled and it doubled again during the year 1929.

In 1926 the Department of Commerce reports 5,782 passengers were transported by airplane operators. In 1927 the total was 8,679. The following year the passenger total made a great advance to 49,713 and during the year 1929 it is estimated 150,000 pas-

(*Continued on page 156*)

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Showing complete line

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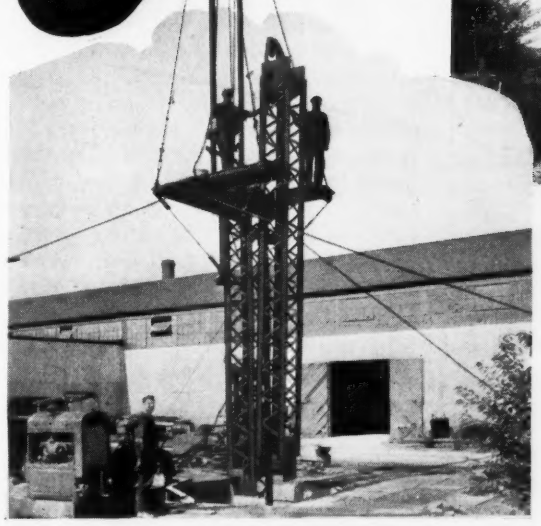

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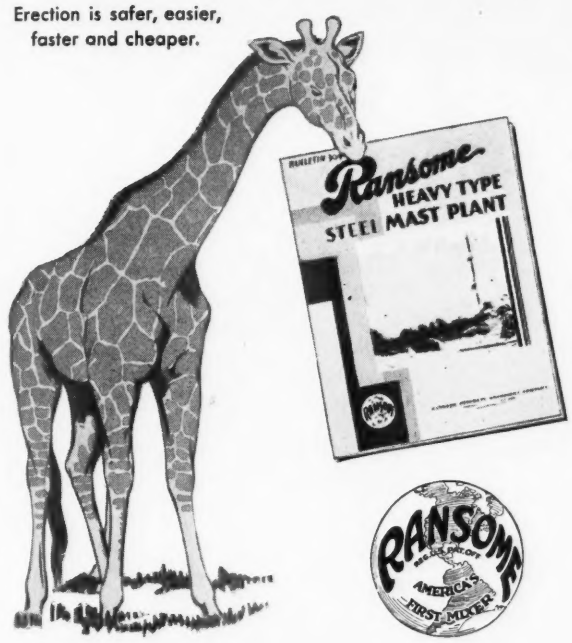
The working platform extends around the mast on three sides, and automatic safety latches are always in position when the platform is being hoisted from section to section. > > >

The Ransome Heavy Type Steel Mast Plant can be used with any of the concrete chuting plants commonly used on construction work—counterweight boom chute plant, continuous line plant or the bin plant. > > > > > > > >

Top and bottom sheaves for raising the sliding frame are furnished as standard equipment. A tip-over bucket in two sizes is offered for use with this mast. These are made in 18 and 36 cu. ft. water level capacity for use with 14-S and 28-S Mixers.

Send for Bulletin No. 304.

Erection is safer, easier, faster and cheaper.



Ransome Concrete Machinery Company

1850 — Service for 80 Years — 1930

Dunellen New Jersey

Commercial Airline Operation

(*Continued from page 154*)

sengers were transported. Again it will be noted that the great bulk of the progress was made during the last two years.

There were six air passenger operators in 1926 and 31 in 1929. There were 18 air transport lines in the United States in 1926 and 97 in 1929. There are no figures on the number of pilots employed in 1926, but in 1927 the total is given as 107 and in 1929 it was 500. In 1926 a total of 2,041 miles of airways had been lighted for night flying; in 1929 there were 12,448 miles lighted.

Under present conditions there are now air lines extending into practically every state of the Union and the few vacant gaps are being rapidly filled. There are four routes giving transcontinental service and other lines extend into Canada and to Central and South America. Four years ago you could not travel by airplane unless you chartered a ship for a special flight and the planes used were totally lacking in passenger accommodations. Now you can go nearly anywhere in an airplane, over a regularly established route, and travel in comfort.

IN the past cost of air travel has been a deterrent to volume. That handicap, however, is being overcome. A year ago an airplane trip cost an average of 11 cents per mile; now that cost has been reduced to an average of 7.8 cents per mile, which is about the charge for de luxe rail travel, and in some instances it is lower. The low rates have brought about an increase in the volume of travel, but they have not solved the problem for the airplane operators. The need is for airplanes that can be operated more economically than those now in use. With the tariffs now in effect a financial profit might be shown if capacity loads could be had at all times, but all transportation experience demonstrates that capacity loads are the exception, not the rule. The traffic expert will say the operator should not figure upon more than 60 per cent capacity, and he is right. But with such loads, air transport operators cannot, with possibly a few exceptions, make a profit under present tariffs if the profit must come entirely from the carrying of passengers.

Fred Goodcell is best known as a newspaper and magazine writer, having been engaged in such work for more than thirty years. He has been a student of airplane transportation for twelve years and for the last three years has been with Western Air Express. He has watched this company grow from a one-line organization, with twenty employees and five airplanes, flying 1,200 miles daily, to an organization employing more than 600 people, with fourteen airplane routes, operating more than 50 airplanes and flying more than 14,500 miles daily.

The airplane will never supersede or displace any of the older transport mediums. It will work in harmony with them and it should prove of tremendous time-saving value to the traveler. For scenic beauty, nothing compares with the airplane trip. In comfort, the modern air liner rivals the finest Pullman. In speed, the airplane has no equal and its accomplishments have just begun. Within five years, maybe two years, a trip across the continent in one day should be possible and probably at a cost no greater than is now charged for the journey from New York to Chicago.

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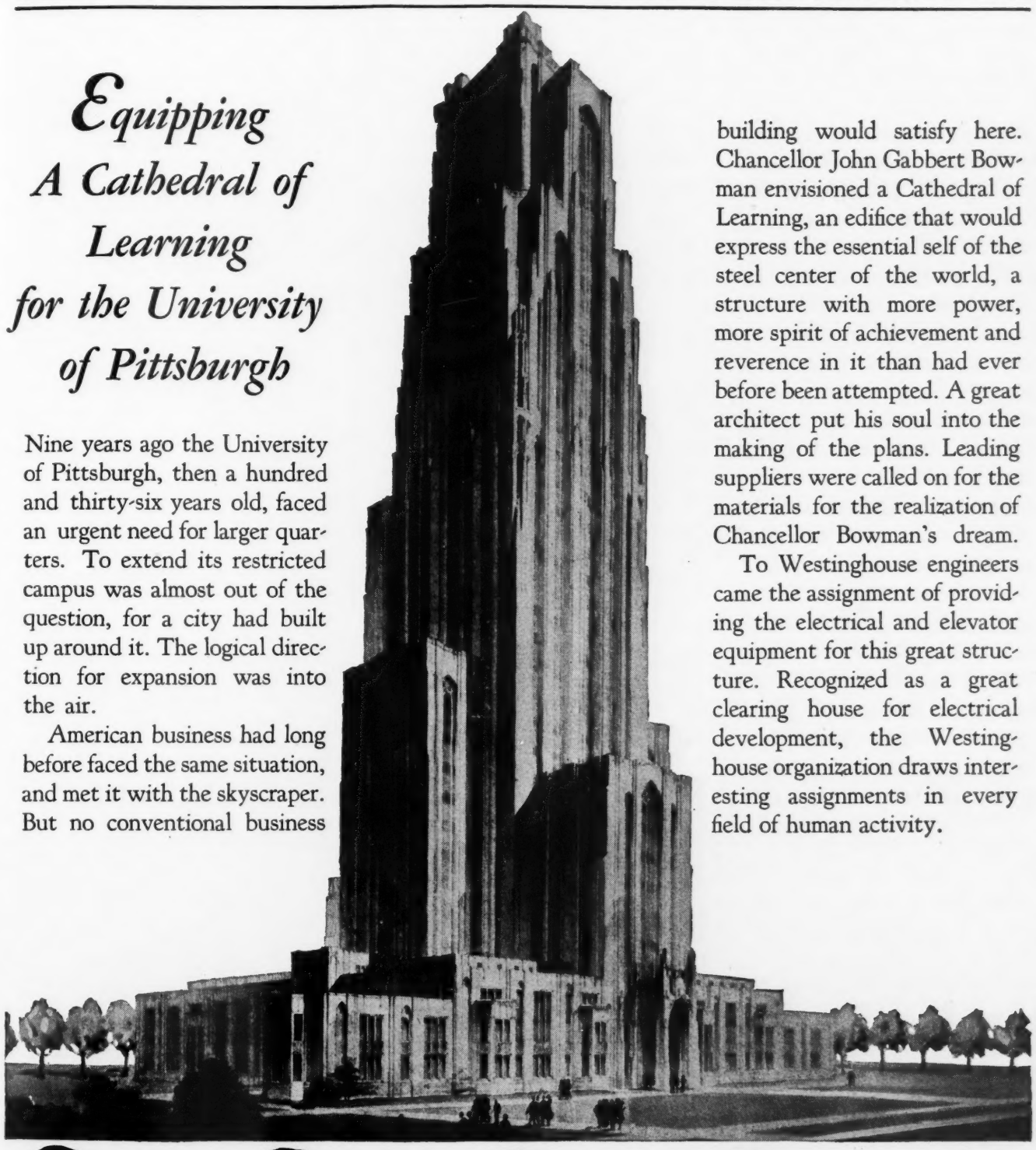
WHAT YOUNGER COLLEGE MEN ARE DOING WITH WESTINGHOUSE

Equipping A Cathedral of Learning for the University of Pittsburgh

Nine years ago the University of Pittsburgh, then a hundred and thirty-six years old, faced an urgent need for larger quarters. To extend its restricted campus was almost out of the question, for a city had built up around it. The logical direction for expansion was into the air.

American business had long before faced the same situation, and met it with the skyscraper. But no conventional business building would satisfy here. Chancellor John Gabbert Bowman envisioned a Cathedral of Learning, an edifice that would express the essential self of the steel center of the world, a structure with more power, more spirit of achievement and reverence in it than had ever before been attempted. A great architect put his soul into the making of the plans. Leading suppliers were called on for the materials for the realization of Chancellor Bowman's dream.

To Westinghouse engineers came the assignment of providing the electrical and elevator equipment for this great structure. Recognized as a great clearing house for electrical development, the Westinghouse organization draws interesting assignments in every field of human activity.



H. O. KOEHLER
University of Illinois, '22
Application Engineer

H. J. PETERSON
University of Washington, '26
Control Engineer

E. N. BALDWIN
Purdue University, '22
Engineer of Mechanical Design

R. A. GAUT
Pennsylvania State College, '25
Field Engineer

C. F. CARNEY
University of California, '26
Control Engineer

Westinghouse

The Construction of an All-Metal Flying-Boat

(*Continued from page 136*)

THE "Commodore" wing, which is of normal two-spar design, is braced with Warren type trusses in the planes of the front and rear spars. The structure is braced against unbalanced loads by means of tie-rods extending from the hull center-line fitting to the center-section end fittings. Crossed tie rods, in fore-and-aft planes brace the outboard floats against loads in the drag direction.

The wing is made in three panels, an 18-foot center section and two outer panels, each 41 feet in length, making a span of 100 feet from tip to tip. The chord is constant at 138 inches, there is no sweep back, and the outer panels have 2 degrees dihedral. With the exception of the diagonal drag bracing, all the main structure is of duralumin.

The spar design was developed as a result of a static test on an outer panel front spar. From this test, design methods were developed which could be applied to other spars of similar construction; that is, reliable methods were determined for computing the actual and allowable stresses. The compressive strength of each type of web member was also determined by static test. In order to duplicate as nearly as possible the actual working conditions, each test specimen was riveted between two short lengths of bulb tee section just as it would be in the actual spar.

In the center section, the presence of gasoline tanks which occupy most of the space between spars, makes the use of the usual strut-and-wire-drag bracing impracticable. A metal covering of sufficient strength and rigidity to carry the drag shears was therefore designed for the upper surface of that portion of the wing, between spars only. It consists of a corrugated duralumin sheet having the corrugations parallel to the spars, with a smooth sheet of the same material riveted to the outer surface. Additional stiffness was provided by a number of extruded duralumin angles running normal to the spars. The lower spar flanges are given lateral support by four longitudinal members which act as supporting beams for the gas tanks. The metal covering also serves as a walk-way over the center section.

The "Commodore" ribs are of the truss type and are made up as a unit, *i.e.*, the cap strips are continuous over both front and rear spars. Both the cap strips and the trussing are formed from a special channel section having the outstanding legs flanged in. This section, which is drawn from .020 duralumin strip, combines the advantages of comparative cheapness with good structural efficiency. It is also adaptable to a simple type of joint made with standardized duralumin forgings.

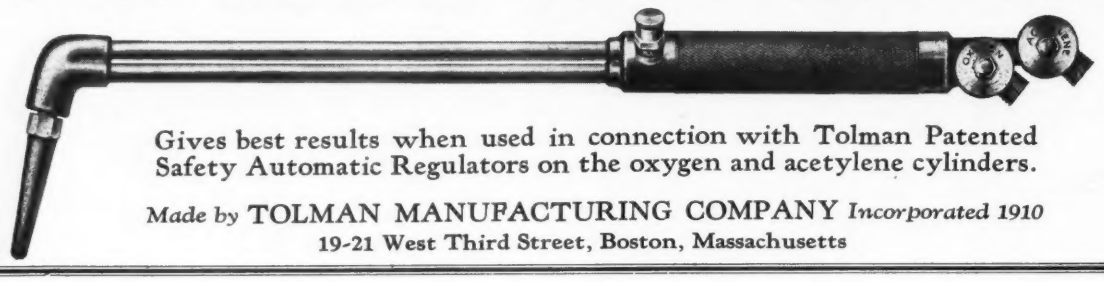
G. Garner Green and F. R. Shanley are two of the junior members of the Consolidated Aircraft engineering staff. Mr. Green is a graduate of the Aeronautics Department at Stanford University; Mr. Shanley was graduated from Penn State as a Mechanical Engineer. They have worked on the design and structural analysis of the "Commodore" throughout its development, under the supervision of Mr. I. M. Laddon, the designer.

THE control surfaces, like the wing panels, are of fabric-covered, duralumin construction. The aileron spars are of the truss type with plane angle chord members and light channel web members. Torsional strength and rigidity is provided by a box-like structure of duralumin sheet, suitably stiffened with bulkheads. This box structure is shaped to give the aileron the desired nose contour. A structure of this type is very convenient for the Frise type aileron used on the "Commodore." The ribs consist of formed, channel section cap-strips and zee-section vertical web members.

The design of the stabilizer, elevator and rudder, which are externally braced, is essentially the same. The front and rear elevator spars are of the truss type, built up of extruded sections. The torsion members of both the elevator and the rudders are box sections constructed of duralumin sheet. The ribs are similar to those used in the ailerons.

The fabric-covered, metal-structure type of construction used in the "Commodore" wings and control surfaces has several distinct advantages over all-metal construction, particularly as applied to externally braced structures. In such designs, a stiff covering is not usually required as a means of obtaining torsional strength and rigidity so that unless the metal covering can be made to resist some of the bending moment, as it is not, in most cases, it is just so much excess baggage. The stresses due to drag loads can be handled much more efficiently by the usual tie-rod drag bracing. In nearly every case, the fabric-covered structure can be made lighter than the corresponding metal-covered job. Then, the fabric-covered wing can usually be built more easily and cheaply. Metal-covered wings nearly always entail an excessive amount of riveting, some of which is sure to be difficult, laborious and expensive. Another important advantage of fabric-covered metal wings over the all-metal type is the greater ease of inspection inherent in the former type. When the fabric is replaced, as it should be at certain intervals, or after a crack-up, the structure can be given a thorough examination for minor failures that could not be observed from the outside, deterioration of the protective coating, and corrosion. With the usual type of metal-covered wing such an inspection is difficult or impossible. This feature should be seriously considered by aircraft operators, who are primarily concerned with the safety of their passengers and the durability of their airplanes.

TOLMAN WELDING AND CUTTING TORCH



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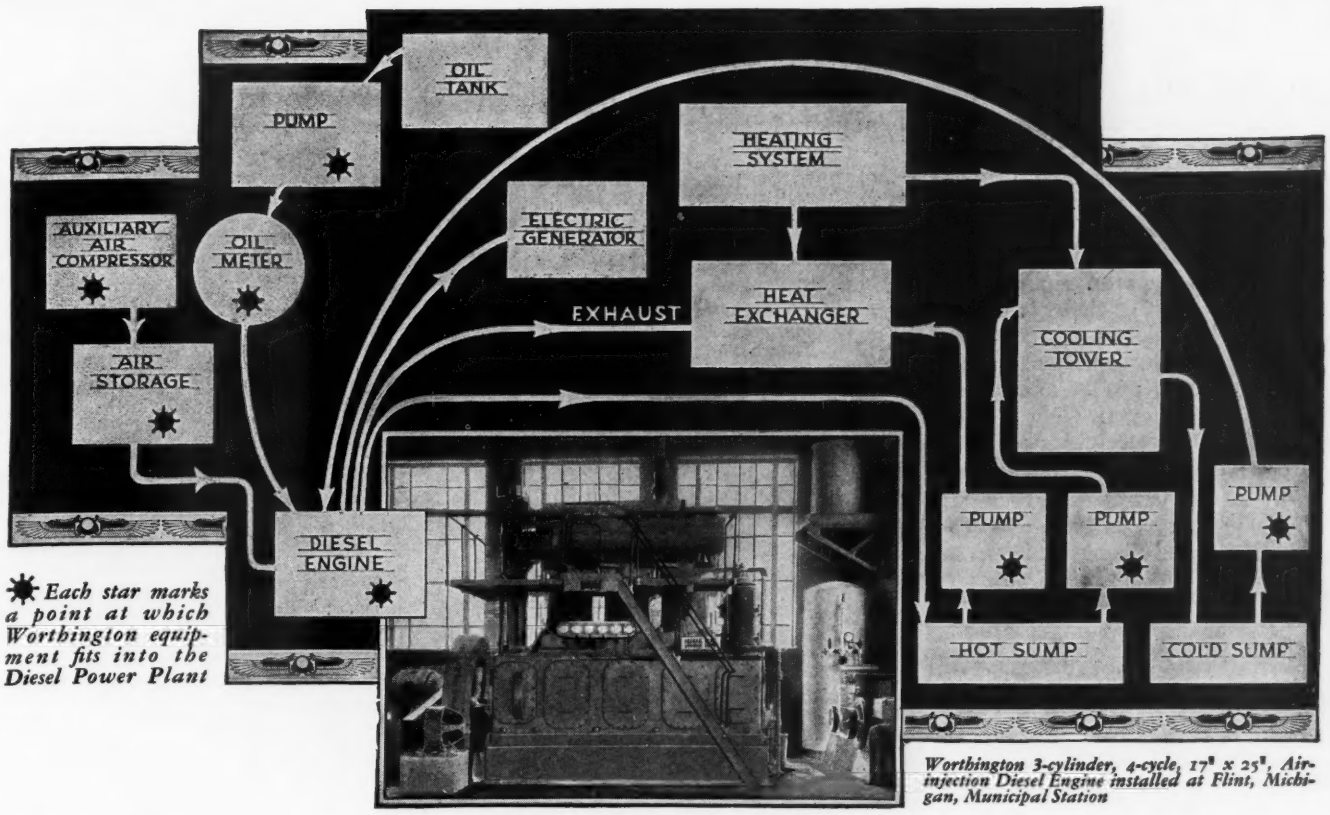

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They wanted dependable low-cost power for their lighting system, and they got it . . . with a modern Worthington 3-cylinder 4-cycle Diesel Engine direct-connected to an a. c. generator.

Now in its third year of service, this unit is rendering steady, dependable service . . . representative of the performance promised for and delivered by *every* Worthington Diesel Engine. *Write for information on this type of equipment.*

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The Diesel Aircraft Engine

(*Continued from page 134*)

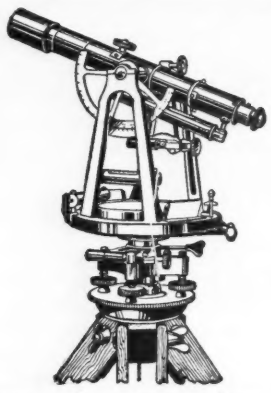
hub instead of being splined or keyed to the crankshaft is allowed to float on an extension of the crankshaft driving-end and specially designed propeller-blade clamp-rings provided with integral driving lugs receive the driving effort from a two-armed driving member splined to the crankshaft. On the extremity of each of these two arms a pair of rubber blocks are compressed between which the propeller clamp-ring driving lug is secured. These rubber blocks are confined in such a manner as to yield the desired elasticity. Here again a marked weight saving is accomplished since the propeller hub can be made of very light construction because it is completely cushioned from any driving shocks. While the elastic connection of the propeller to the crankshaft might in itself aggravate torsional vibration, the inherent damping or hysteresis of the rubber blocks, supplemented by the surface friction in the counterweight mounting, quickly and entirely smooths out the shaft rotation.

TO begin with, it was recognized that the cooling problem of a Diesel cylinder was considerably simpler than that of a corresponding gasoline engine cylinder since the increased thermal efficiency of the Diesel is reflected in far lower heat losses to the cylinder walls than is the case with the gasoline engine cylinder. This fact justified a simple form of closed end cylinder design in which the cylinder head proper is formed integral with the cylinder barrel, a construction which is not considered altogether satisfactory for gasoline engines due to the inferior cooling attained with this type of cylinder head as contrasted with the much more bulky screwed-on aluminum type of head commonly used with gasoline engines.

Furthermore, the fact that only pure air is drawn into the cylinder on the intake stroke of the Diesel permits the novel use of a single valve for both inlet and exhaust purposes in the Packard Diesel, this contributing to a marked degree to the lightness of the cylinder itself since the cylinder head is weakened by only one port instead of two as in the conventional engine. The single valve arrangement has been favored not only on account of the general gain in simplicity and weight saving but also in the interest of reliability since the valve operates at a much lower temperature than the conventional exhaust valve due to the cooling effect of the incoming air passing over the same valve, and furthermore the available time for opening and closing the valve is lengthened appreciably so that lower rates of acceleration thereof can be utilized thus saving wear and tear on the whole mechanism. Bolted to the top of each cylinder is a light aluminum cylinder head carrying cooling fins and supporting the valve operating mechanism as well as forming the combined inlet and exhaust port.

Heretofore the majority of solid fuel injection engines of the so-called high speed type (maximum revolutions about 1,200 r.p.m.) have been characterized by a multiple pump unit mounted somewhere on the engine remote from the cylinder heads in which the nozzles are located and connected to them by comparatively long capillary tubing. With such a system satisfactory high speed operation is very difficult to obtain for several reasons, the principal one being that enormous hydraulic pressures necessary for high speed operation cause serious surges of pressure waves in the tubing which interfere with the correct timing of the fuel injection and also tend to make the engine run unevenly since it is difficult to arrange the tubing to the various cylinders all of the same length. Another difficulty arises from the trapping of air in the capillary tubing which air is difficult to expel and causes the engine to misfire. All of these troubles have been overcome with the Packard fuel injection system since the pump and nozzle are practically one unit with extremely short connecting passages between them.

Captain Woolson was born in Los Angeles in 1888. He received his education in the public schools of Oregon, and the University of London. He received his rank of Captain during the war, when he served in the Air Corps. Identified with aircraft development since 1917, he has been the designer of a number of motors. Probably the most famous of these is the Diesel motor which he designed for the Packard Motor Car Co. Captain Woolson was unfortunately killed April, 1930, in an airplane crash.



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Often wear indicates the desirability of special qualities in the wearing surfaces. Oxwelding provides a rapid and effective means of applying bronze as well as abrasion resisting materials such as Haynes Stellite, thus minimizing the necessity for further renewal.

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The Round Hill Experiment Station

(*Continued from page 137*)

found now at Round Hill a growing research organization provided with the most extensive facilities for work.

THE problems involved in the establishment of an organization of this kind are far from being all of a scientific nature. Not only must shops and laboratories be equipped, but housing facilities must be provided for the staff, administration and maintenance established, and a suitable staff of workers collected. There are at present three laboratories in operation on the estate at Round Hill and two houses which offer comfortable living quarters for the eight men who now constitute the staff.

The first work of the new organization was the establishment of an experimental radio station of the first order. This station is capable of reception at any wave length between 5 and 20,000 meters, and of transmitting from 5 to 100 meters by voice or telegraph. During the past four years communication has been established with stations in every quarter of the globe and detailed observations have been made on the intensity and fading of signals and their dependency on the frequency, the time of day, and the season of the year. The object of the station is, however, to provide a public service as well as collect data of scientific value. It has maintained regular communication with various expeditions, among which may be mentioned the MacMillan expeditions, the non-magnetic ship *Carnegie* until the time of her recent destruction in the South Seas, and more recently the Byrd expedition at the South Pole. The Graf Zeppelin was followed continually on its first transatlantic flight, and at the time of the Vermont floods in 1927 a great service was rendered when a portable transmitter was sent in to the devastated regions by automobile to provide for several days the only channel of communication to the outer world. Another service to the radio public is the transmission at stated intervals of signals of standard frequency, the precision of which now exceeds 0.001 per cent.

DURING the past two years Colonel Green has supplemented his interest in radio communication problems by the active promotion of aeronautics. An airport satisfying the government regulations for a first-class experimental flying field has been developed on the estate and during a large part of the year is the scene of great activity. In conjunction with the airport the Institute operates a meteorological station under the supervision of Professor Rossby of the Aeronautics Department and his two assistants. This station is equipped with the most modern meteorological apparatus, being in fact for the most part identical with the standard United States Weather Bureau stations. Continuous observations are taken of local weather conditions and a radio operator is assigned to the task of copying down the data sent out daily from Arlington. From this data complete weather maps are made up each day for the entire United States and Canada, and local weather forecasts are made for thirty-six hours. Particular attention is paid to upper air observations and other data useful to aviators.

Of all the hazards that beset aerial navigation, fog is surely the greatest and the most difficult to combat. A ship may lay to or reduce her speed, but even the most ingenious airplane pilot seldom accomplishes such ma-

(*Continued on page 164*)

1855 • SEVENTY-FIFTH ANNIVERSARY • 1930

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White hot rivers of metal, pouring from big cupolas in Crane foundries, are even more thoroughly analyzed, more carefully watched, than the drinking water pouring from a faucet in a well-ordered city.

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From specifications of raw materials to final installation, Crane Co. knows its products and what they will do. How Crane Co. developed the background for this knowledge makes an absorbing story. It is titled *Pioneering in Science*. You are cordially invited to send for your copy. Aside from its interest, you will find it a splendid reference book on the reactions of metals to high temperatures and pressures.

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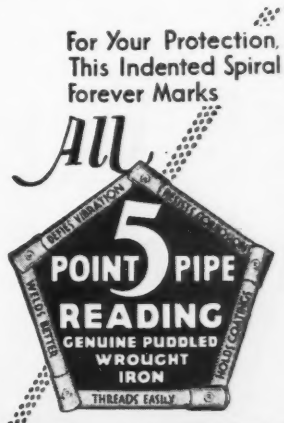

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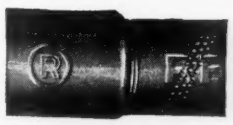

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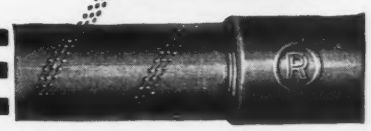

Science and Invention Have Never Found a Satisfactory Substitute for Genuine Puddled Wrought Iron

The Round Hill Experiment Station

(*Continued from page 162*)

neuvers with success. His safety rests entirely with the radio beacons which guide him to the field, his altimeter which determines his height above it, and the chance that at the last moment before landing the fog will not be so dense as to hide completely a view of the field. Surprisingly little is known of the constitution of fog. The various conditions under which it is formed have been studied, but only a few investigators have set themselves the task of analyzing with precision the salts which form the nuclei of fog particles, or determining their size and the amount of liquid water held in unit volume of air. These are the chief aspects of the meteorological research now under way at Round Hill. Microanalysis is being employed to determine the size and nature of the fog particles. Various hypotheses have been offered to explain the source of the nuclear salts and certain consequences of these theories are being checked experimentally in order to eliminate false assumptions.

DURING the past year a part of the staff at Round Hill has devoted itself to a series of experimental and theoretical studies of the absorption of light in fog with a view to determining just what portion of the spectrum could be advantageously utilized. The diversity of aspects which this work presents may well be used as an example of a typical research problem. Curves showing the relation of transmission and frequency can be obtained experimentally over the visible spectrum without undue difficulty. Fog is produced artificially in a long chamber and the response of a photoelectric cell noted as the color of a beam of light falling upon it is varied with the help of filters. If the size of the fog particles and their density are known, it is possible to calculate these same curves from purely theoretical considerations and to extend them into the region where experimental methods are exceedingly difficult. From these calculated curves it should, in turn, be possible to draw conclusions as to the advisability of further experimental work in specific regions. So it is that theory and experiment should be, not competitive, but mutually assisting.

Recent Books

(*Continued from page 146*)

aircraft use. Dead reckoning involves but a few simple principles which, if once mastered, make possible the solution of large numbers of practical problems.

Because of its greater difficulty, aerial astronomy is given more space than dead reckoning in his book. Descriptions are given of the instruments used, which had to be especially developed for aircraft use, and as with dead reckoning, illustrative problems are given showing how the aircraft's position is worked out. To become really proficient in aerial astronomy would, however, require that a great deal more time be spent in its study than is required for dead reckoning, and while Lieutenant Ramsey's book gives a very good introduction to this branch of navigation, for practical use it would have to be supplemented with additional texts and problems.

Some space is also given in the book to the application of meteorology to flying, and descriptions are briefly given of navigational instruments and maps.

A. B. B.

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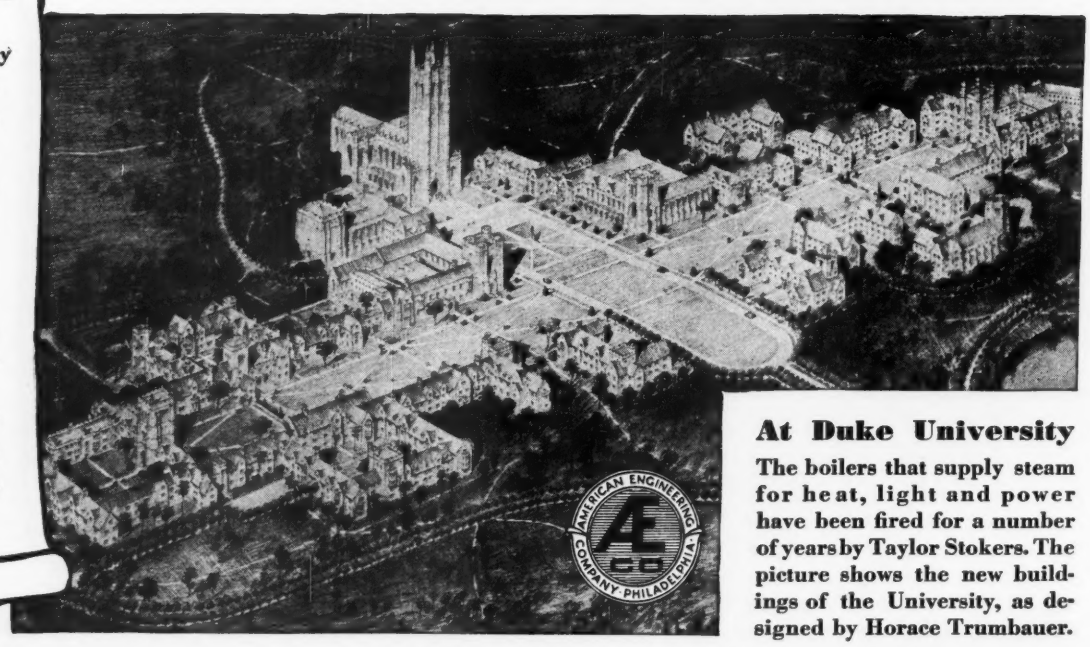

At Duke University

The boilers that supply steam for heat, light and power have been fired for a number of years by Taylor Stokers. The picture shows the new buildings of the University, as designed by Horace Trumbauer.

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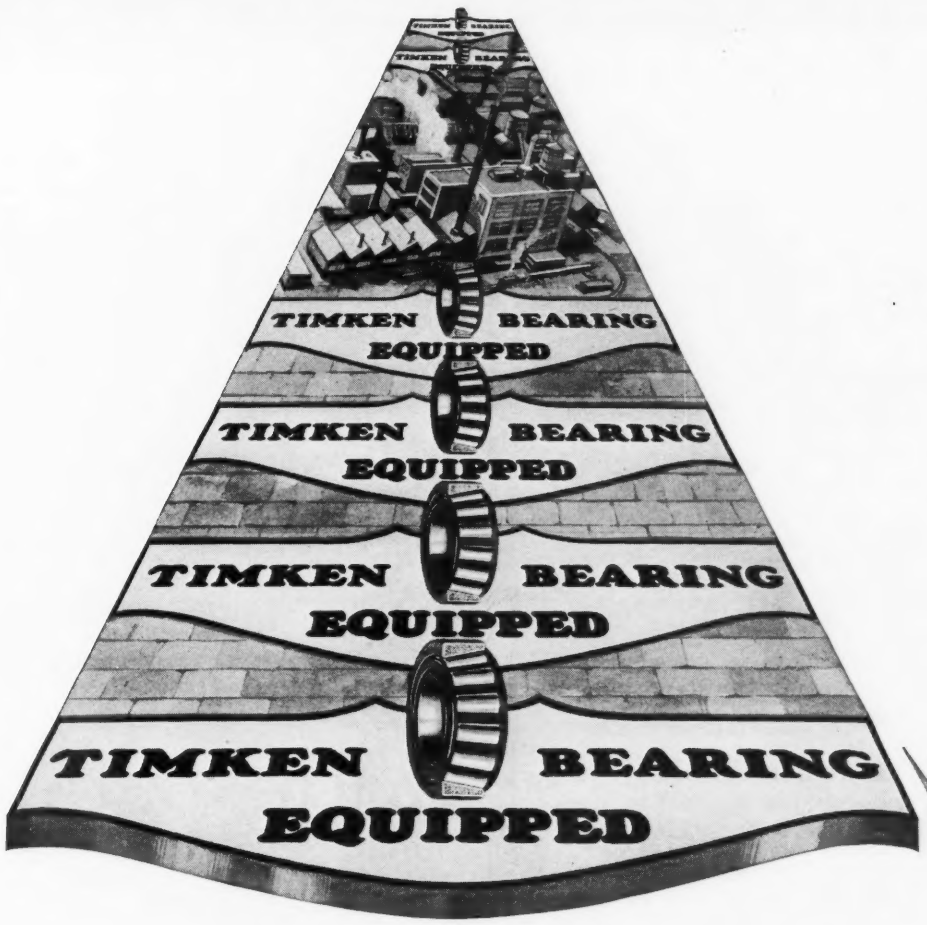

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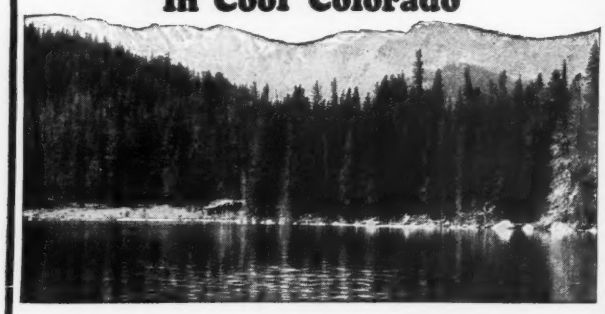

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Departmental Notes

(*Continued from page 144*)

courses to civil engineers much attention is given the study of such subjects (see TECH ENGINEERING NEWS, December, 1929). It is not intended to make professional geologists of civil engineers, but they should know enough to judge simpler cases and realize when it will be necessary to call for geologic expert aid. A specialized course in engineering geology is given to students in Course XII. The Department looks forward to a large development in this field, including an experimental laboratory for the study of undisturbed structures of soil and rock. A thorough knowledge of the soils — that inconspicuous product of decomposition of rocks — is no less important for the civil engineers than for the process of agriculture.

A large part of the activity of the Department relates to advanced research work. At least three new textbooks are in preparation by members of the Department, for science ever marches on and its latest phases must be incorporated in such books. Individual research work is carried on by professors, instructors and students, on many and varied subjects, such as the structure of ores, description of new districts, experiments related to the origin of ores and other more purely geological subjects.

Of late years geology and mining have been aided very materially by another application of the abstract sciences, wholly unexpected only a few years ago except for certain magnetic observations. At the present time orebodies, oil deposits, salt deposits, geological structures are discovered by magnetic, electric, seismic and gravity methods. This new applied science is a child of physics and geology, both being indispensable, and the results have surpassed all expectations.

During the next year a new course of lectures will be established dealing with geophysics, that is the knowledge of the composition and structure of the earth and the behavior of the earth and its components in gravitational, electric, magnetic and seismic fields. The discovery of new bodies of mineral deposits is thus now essentially a problem of geology and physics. The methods employed in actual practice will be taught in coöperation with the Mining Department.

WALDEMAR LINDGREN,
In charge, Department of Geology.

Aeronautical Electives

(*Continued from page 138*)

In 1927, the increase in manufacturing cost almost doubled the cost of a plane. Production schedules were not modified, and overproduction resulted. Retrenchment was necessary. The industry is now unstable and in the future many failures and combinations are expected. A few large companies will then arise requiring specialized engineering staffs.

IT is for this reason that Course XVI has been changed to incorporate electives permitting a student to specialize in the design and analysis of airplanes, in the design of aircraft engines, in the commercial operation of aircraft, or to prepare himself to undertake aerodynamic research. The electives cover about a quarter of the time required in the second term of the senior year and will give the undergraduate an opportunity to specialize on the branch in which he is most interested without sacrificing any of the subjects which are fundamental in the training of all engineers.

Elective *a*, "Airplane Design Problems," requires twelve hours a week and is intended to acquaint the student

(*Continued on page 170*)

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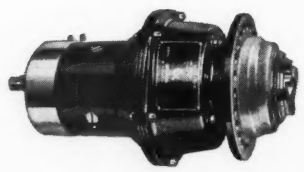
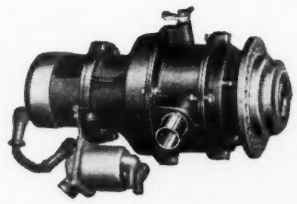
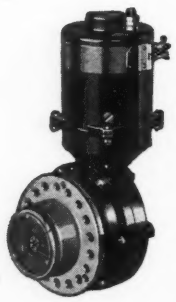


Eclipse direct cranking electric starter type F-141 for engines up to 800 cu. in. piston displacement.



Eclipse, Series 6, Combination Hand and Electric Inertia Starter with Solenoid Switch. Concentric type for radial engines up to 1350 cu. in. piston displacement.



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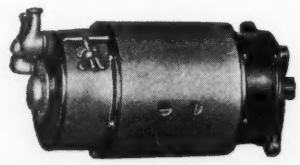

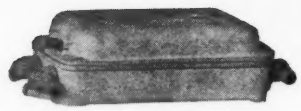

Eclipse voltage-regulated generator 15 volt, 25 ampere capacity, engine driven type with control box.

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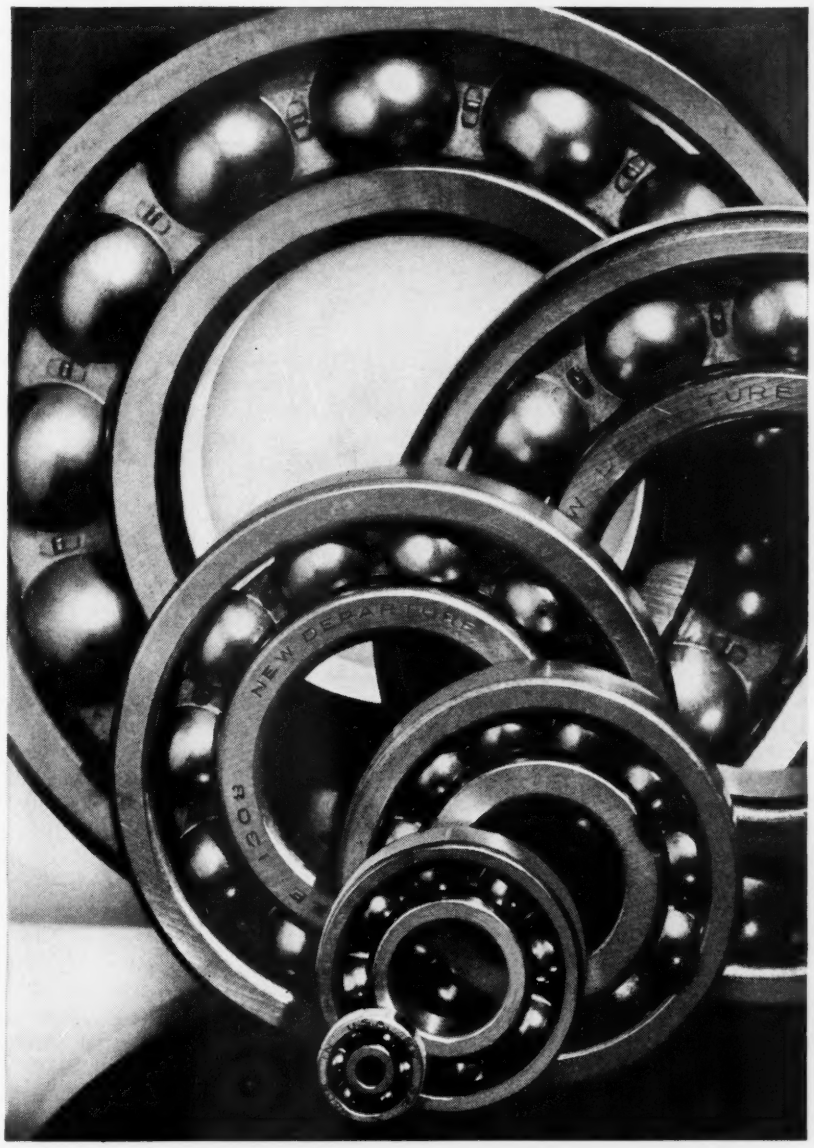

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Aeronautical Engineering Electives

(*Continued from page 168*)

with some of the problems common to the design of airplanes and to develop his ability to approach and analyze them in a rational manner. It is directed toward the development of men who wish to design and manufacture airplanes.

Elective *b*, "Airplane Engines," covers the same time per week and is directed toward the training of men interested in the development of aircraft power plants. Part of the time is devoted to lectures, part to laboratory classes; and the intention is to give a sound basic training in the art of engine design, operation and maintenance.

The third elective covers the commercial operation of aircraft and includes a course in elementary meteorology. It deals with the financing, construction and operation of airways, and the determination of rates so that they may be successful — in theory at least — and is intended to permit a graduate to enter the employ of a transport company.

The fourth elective is designed for men who wish to carry on the important work of research in the field of aerodynamics. It provides more work in the wind tunnel with lectures on the technic of operations and the methods adopted to the solution of various problems.

In addition to these electives in the course in Aeronautical Engineering, there has been added an elective in Airway Transportation in the Transportation Option offered by the Department of Civil Engineering. This elective, Option 2C, introduces the student to the nomenclature and the more elementary problems of aeronautics in the first term of the senior year and devotes sixteen hours a week to the problems of hangar design and airplane stress analysis, and to the commercial operation of aircraft during the second term. While it may appear to conflict with the third elective in aeronautical engineering, the actual duplication is slight. The elective in aeronautical engineering is designed to give a man who is primarily interested in the construction and operation of aircraft a knowledge of the problems of providing and maintaining suitable airports, whereas the elective in civil engineering is fashioned to give a man who is primarily interested in the design, draining and construction of airports a knowledge of the operation of airplanes and airways.

As was stated above, these courses have been laid out to meet present conditions in the industry and have been influenced to some extent by the assumption that aviation is basically sound and that it will be stabilized during the next year or two so that the demand will be more for young engineers who have a specialty than has been the case during the past three years.

While it may be somewhat foreign to the subject under consideration it might not be amiss to remark that no boom in aeronautics comparable to that which started in 1927 is anticipated for the next few years. It is hoped and expected that the development will be steady and that the public's interest in aviation will not wane until the younger, more air-minded generation, those who are in the elementary and high schools of the country at present, have reached man's estate and have accumulated the resources — or credit perhaps — necessary for the purchase and operation of their own airplanes. This should occur within the next ten years and when it does the status of the aeronautics world will change. Requirements will change, and courses of training for aeronautical engineers will have to be altered to suit the new requirements, but it is deemed both undesirable and unnecessary at this time to hazard even a guess as to what they will be.

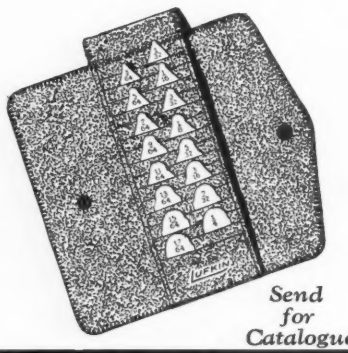
Meteorological Research

(*Continued from page 135*)

arrive everywhere at a higher temperature than that of the surroundings. It will then continue to rise with increasing velocity and the eddy motion will receive added impetus. This unstable condition is characteristic of the tropics and the warm season.

Thus the state of turbulence not only affects the temperature distribution in the atmosphere but is itself essentially determined by the latter. This is beautifully illustrated by the dense haze and smoke layers prevalent over industrial areas in fair weather periods during the cold season. Due to radiation from the ground, the lower strata are rapidly cooled to very low temperatures, while the air at some elevation above the ground may be quite warm. The resulting temperature inversion is very stable.

BEFORE closing, I would like to draw the attention of the reader to another aspect of meteorological training which, I believe, is not sufficiently recognized in the United States. The methods used in the study of atmospheric motion can, without great change, be transplanted into oceanography and utilized in the study of ocean currents. The one contribution which V. Bjerknes rates highest of all his work in meteorology, namely the circulation theorem connecting the field of motion with the fields of mass and pressure, is more and more becoming the standard tool in charting the ocean currents. The turbulence theory sketched in this paper was developed parallel for the ocean and the atmosphere and has enabled us to understand the veering of surface drift currents with depth. Thus the methods and results of theoretical meteorology often have a scope and applicability extending beyond meteorology into physical oceanography, but also into various other branches of geophysics.



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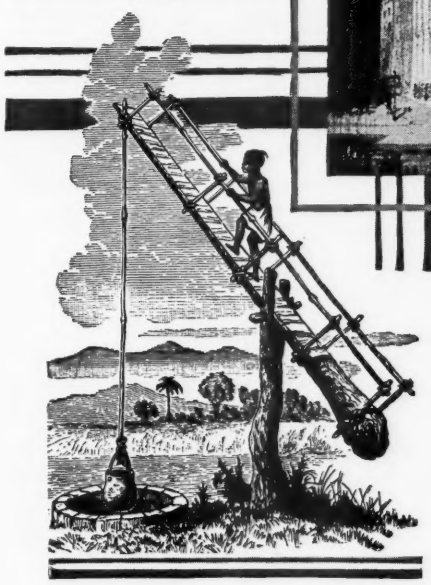

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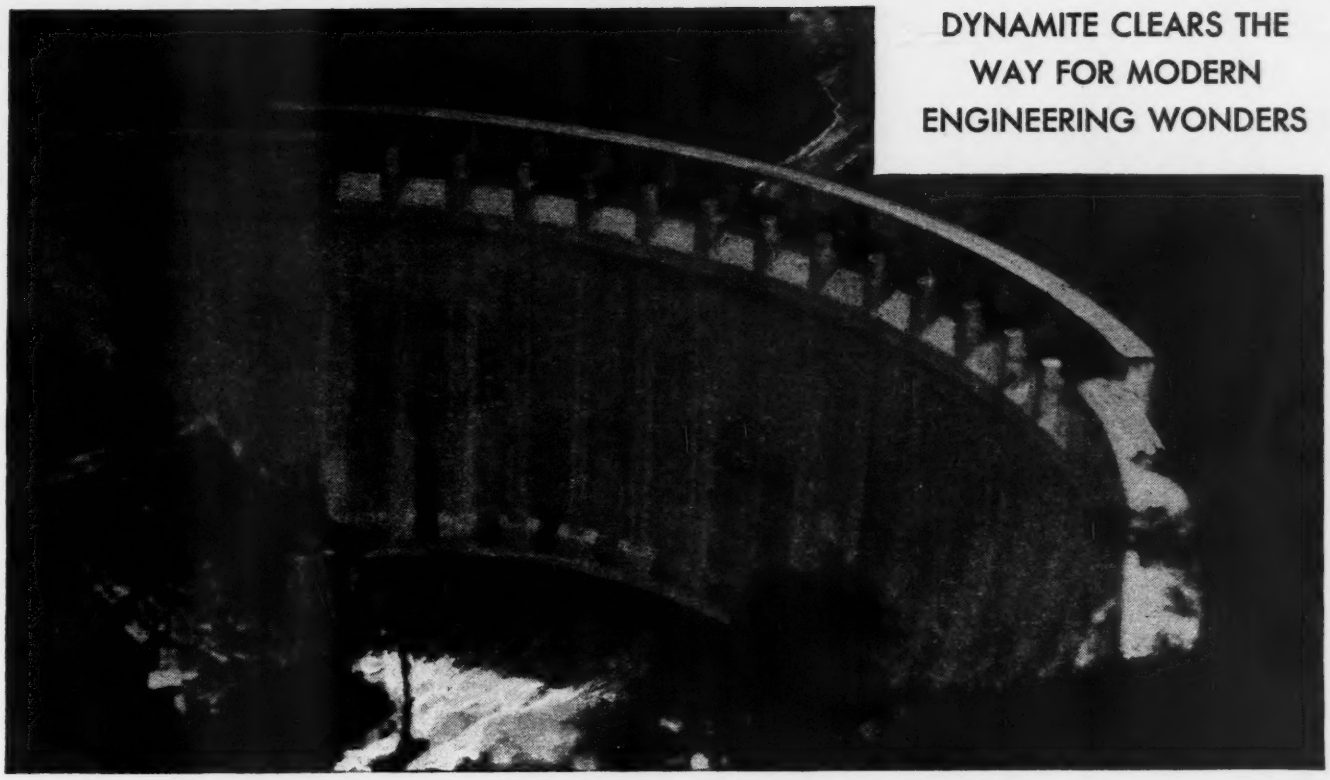

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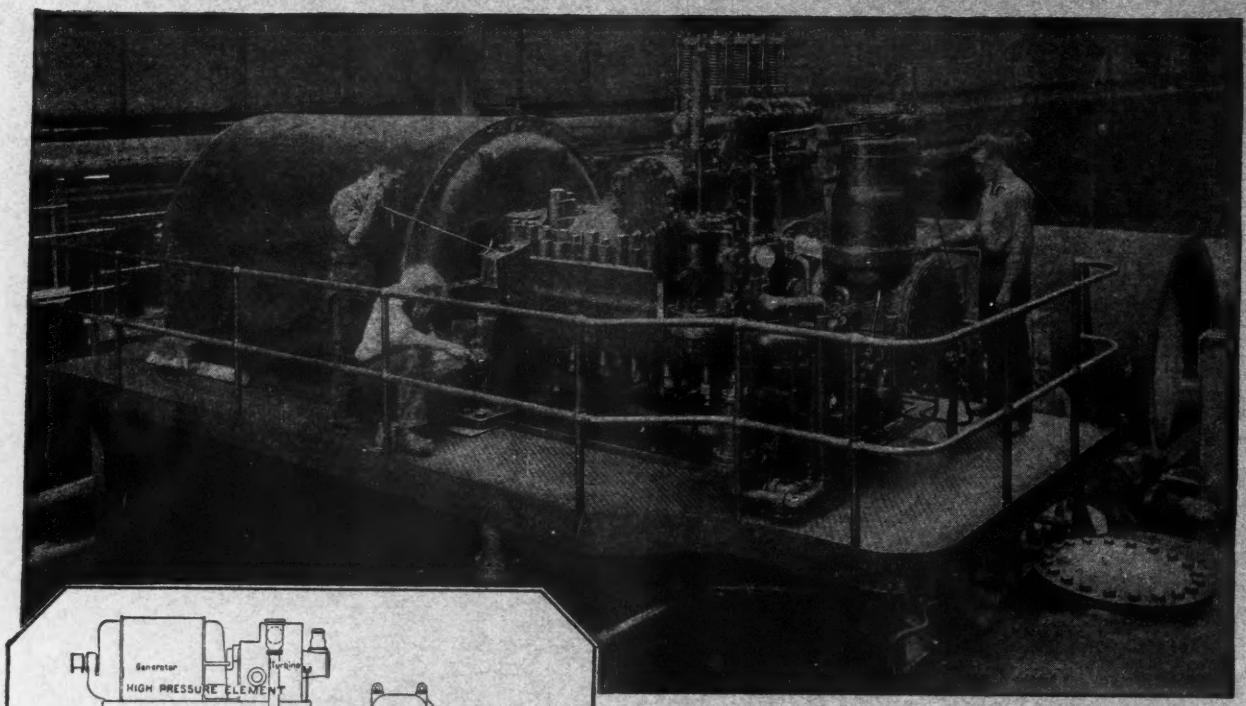

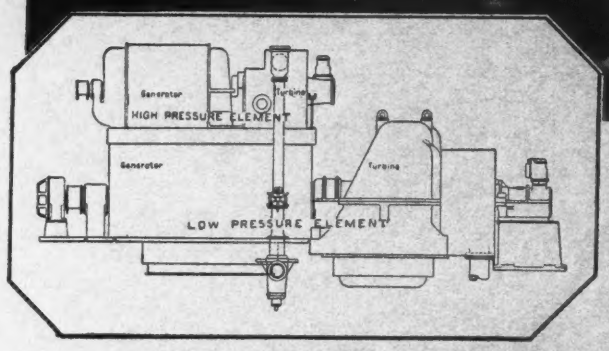

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